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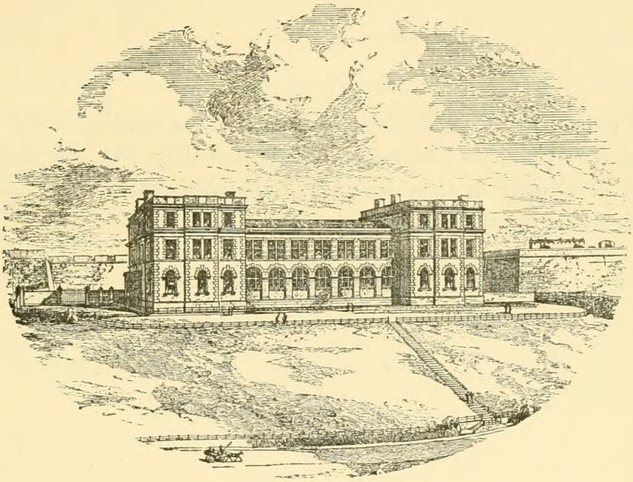
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

VOLUME III (N.S.).

1893–95.

PLYMOUTH:
PUBLISHED BY THE ASSOCIATION.

Agents in London:—Messrs. DULAU & Co., 37, Soho Square, W.

The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for the accuracy of statements published in this Journal, excepting when those statements are contained in an official report of the Council.

2678

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(NEW SERIES.)

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Director's Report.—No. I.

Of the work undertaken during the winter 1892-3, and before my arrival at Plymouth in April, I must report that, as in the preceding winter, the anchovy nets were shot by the fishermen to whom they were entrusted, but unfortunately without satisfactory results.

In consequence of representations made to the Devon Sea Fisheries Committee and also to the Board of Trade by my predecessor, Mr. Calderwood, the following addition has been made by the Board of Trade to the Bye-laws which were submitted to them by the Committee for revision :

"Nothing in these Bye-laws contained shall apply to a person fishing solely for scientific purposes, under the written authority on that behalf of the Local Fisheries Committee of that district, signed by their clerk, and subject to the conditions contained in that authority." The permit in question will be granted, in due course, to the fishermen working for the Laboratory.

Under the regulations which fixed the shortest term for the renting of a table in the Laboratory at a month, but few workers have visited us during the short Christmas and Easter vacations. Now that the minimum charge is for one week (at the rate of thirty shillings), facilities are given for a short stay at Plymouth. This should induce investigators to take any opportunity which may occur at any time of the year to collect seasonable material, or to study living animals and plants available for the time being. The weekly announcements in "Nature" of new finds, of the composition of the Plankton, and of the animals breeding, will, it is hoped, prove useful by indicating what special material is being procured during the ordinary course of dredging and tow-netting.

Dr. S. J. Hickson continued his studies on Alcyonium last Christmas. During the month of April, Mr. Riches recommenced his word on the Nemertines of Plymouth ; Mr. Maurice S. Evans, F.Z.S., F.R.G.S., was instructed in the methods of collecting and preserving marine animals before his return to Natal. Dr. G. J. Romanes, a Governor of the Association, sent his representative to occupy a table.

The sea water circulating through the Laboratory tanks and those in the Aquarium is in excellent condition, and has recently stood a severe test in a perfectly satisfactory manner. Mr. Cunningham has succeeded in rearing young flounders through their earliest and most critical stages in the tanks of the Laboratory. This fact speaks very well for the purity of the sea water, and certain modifications of the arrangements for pumping and storing the water will ensure the continuance of this favorable condition of things regarding what is, without doubt, the most important factor in almost all the research carried on at the Laboratory.

The nature and scope of the results obtained by the naturalists of the Association is amply testified by the contents of the present number of the Journal. The papers by Mr. Riches and Mr. Gamble are important contributions to the fauna of the English Channel, and in conjunction with the faunistic work which is being carried on by Mr. Garstang, show great advance towards a more complete and detailed knowledge of the rich and varied fauna in the immediate neighbourhood of Plymouth.

EDWARD J. BLES.

May, 1893.

Marine Biological Association of the United Kingdom.

Report of the Council, 1892-93.

The Council.

During the past year the Council has held eight meetings for the conduct of the business of the Association, of which the meeting on May 20th and 22nd was held at the Plymouth Laboratory.

Sir Albert Rollit, M.P., Mr. W. T. Thiselton Dyer, C.B., C.M.G., and Mr. Frank Crisp, V.P.L.S., have retired in the course of the year, owing to the numerous calls upon their time: the first vacancy was filled by the election of Prof. W. C. McIntosh, F.R.S.; the others are to be filled at the General Meeting.

As in previous years, the Council has pleasure in acknowledging the courtesy of the Royal Society in permitting the use of its rooms for the several meetings of the Association.

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MARINE BIOLOGICAL LABORATORY.

Received June 1898.
Accession No. 1531.
Given by Marine Biol. Assoc.
Place,

*** No book or pamphlet is to be removed from the Laboratory without the permission of the Trustees.

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The Plymouth Laboratory.

The buildings, fittings, and machinery of the Laboratory are in a satisfactory condition, and have not necessitated any special outlay. A small sum has been spent in painting and wainscoting the Tank Room.

The Boats.

The question of the boats has occupied the Council very seriously during the past year. The old steam-launch "Firefly" is still at work, although it was decided to replace her a year ago. A new steam-launch, of about the same size as the "Firefly," was recently purchased, but has proved to be unsuitable for rough work. The little sailin boat "Anton Dohrn" is in excellent repair, and continues to be very useful.

As the work of the Association increases, the need of a deep-sea-going boat is constantly more pressing, but there are no funds in hand sufficient for its purchase and maintenance. This need has been particularly felt of late in the fishery inquiries in which the Association has been engaged in the North Sea as well as at Plymouth.

The Library.

The Library continues to make steady progress. Among the more important additions during the past year are the Fishery publications of England, Scotland, and Ireland; of the United States, Canada, and Newfoundland; of Germany, the Netherlands, Norway, Sweden, and France (Marseilles). Important contributions relating to the German Plankton Expedition, and to the cruises of H.H. the Prince of Monaco have also been added. Valuable gifts of their publications have also been made by the Royal Society, the Zoological Society, the Royal Microscopical Society, the Harvard Museum, the Australian Museum, the Bergen Museum, the College of Science at Tokīo, the Royal Society of Victoria, the Natural History Societies of Denmark, Norway, the Netherlands, Boston (U.S.), and others. To these Societies, and to the numerous donors of books and papers, the Council render the thanks of the Association.

The Museum.

The type-collection is increasing satisfactorily under Mr. Garstang's care.

In addition to the specimens at Plymouth, a series of selected specimens has been arranged and mounted for exhibition, and has been greatly admired on the six occasions when it has been shown, namely, the second Conversazione of the Royal Society, 1892; the Conversazione of the Sheffield Literary and Philosophical Society, 1892; the Soirée of the Royal Microscopical Society, 1892; the Sea Fisheries Conference, Fishmongers' Hall, 1893; the two Soirées of the Royal Society, 1893. This exhibition series is being enlarged.

The Staff.

The Council in January last accepted Mr. Calderwood's resignation of the office of Director, and appointed Mr. E. J. Bles, B.Sc., late Honorary Research Fellow of the Owens College, Manchester, in his place. Mr. Bles entered upon his duties on April 12th of this year.

Owing to the generosity of Mr. J. P. Thomasson, who has made a second donation of £250 for this purpose, it has been possible for the Council to retain the services of Mr. Holt for fishing inquiries in the North Sea for a second year.

Mr. Garstang has been appointed for a second year to superintend the collection, preservation, and supply of material. The character of the specimens supplied by the Laboratory has improved very greatly under his care.

Scientific Investigations.

Mr. Cunningham has continued his observations on the rate of growth and probable ages of young fish, a paper on which was published in the November number of the Journal. He has also continued his experiments on the colouration of the underside of flatfishes. Since Christmas he has been occupied in an inquiry into the question of the destruction of immature fish, the first results of which appear in the May number of the Journal.

Mr. Cunningham has also succeeded in artificially fertilising the eggs of the flounders which he has reared in the Laboratory tanks during the last three years from a length of half an inch; the eggs developed, and the larvæ were artificially fed for ten days after the absorption of the yolk-sac. This result is of great importance and interest.

Mr. Holt has been at work now for eighteen months upon an investigation of the fisheries of the North Sea, and his papers in the Journals for November and May supply a large amount of important information. The Council contribute to the expenses of the Cleethorpes Aquarium of the Marine Fisheries Society (Grimsby) in return for Mr. Holt's use of their Laboratory and tanks.

Mr. Garstang has captured a large number of rare forms during the past year, on which and on other points of interest he contributes a weekly note in 'Nature,' and he has added five new species to the list of the British fauna. As a result of his work during the past year, an intimate knowledge of the localities of the fauna has been acquired, so that specimens can be obtained without delay.

Occupation of Tables.

The following naturalists have occupied tables in the Laboratory during the past twelve months:

E. J. Allen, B.Sc., University College, London (Development of Palæmonetes).
E. J. Bles, B.Sc., The Owens College, Manchester (Pelagic Fauna).
F. J. Cole, Assistant to G. J. Romanes, Esq., F.R.S. (Pleuronectid larvæ).
F. W. Gamble, B.Sc., The Owens College, Manchester (Turbellaria).
R. T. Günther, B.A., Oxford (Development of Cephalopoda).
S. J. Hickson, M.A., D.Sc., Cambridge (Alcyonium).
Gregg Wilson, Edinburgh, (Senses of Fishes).

Mr. M. S. Evans, F.Z.S., of Natal, also attended the Laboratory in order to learn the best methods for the preservation of animals.

In addition to those which have appeared in the Journal, the following papers, the outcome of studies made in the Laboratory, have appeared in the publications of learned Societies and in scientific periodicals since the publication of the last list (Journ. M. B. A., ii, 281) :

Allen, E. J.—*The Nephridia and Body-cavity of some Decapod Crustacea,* Quart. Journ. Micr. Sci., xxxiv, 403.

Gamble, F. W.—*Contributions to a Knowledge of British Marine Turbellaria,* Quart. Journ. Micr. Sci., xxxiv, 433.

Garstang, W.—*The Development of the Stigmata in Ascidians,* Proc. Roy. Soc., li, 505.

—— *On some New or Rare Marine Animals discovered on the Coast of Devonshire,* Trans. Devon. Ass., 1892, 377.

—— *On the Structure and Habits of* Jorunna Johnstoni, Conchologist, ii, 1.

Groom, T. T.—*On the Early Development of Cirrhipedia,* Proc. Roy. Soc., lii, 158.

Minchin, E. A.—*Observations on the Gregarines of Holothurians,* Quart. Journ. Micr. Sci., xxxiv, 279.

Weldon, W. F. R.—*Certain Correlated Variations in* Crangon vulgaris, Proc. Roy. Soc., li, 1.

Willey, A.—*Observations on the Post-embryonic Development of* Ciona intestinalis *and* Clavelina lepadiformis, Proc. Roy. Soc., li, 513.

—— *Studies on the Protochordata,* Quart. Journ. Micr. Sci., xxxiv, 317.

Select Committee of the House of Commons on Sea Fisheries.

This Committee was nominated to inquire into possible measures for the improvement and preservation of British Sea Fisheries. A Committee of the Council was appointed to consider the extent and form of the evidence which the Association could tender; and Prof. Lankester, Dr. Günther, Mr. Cunningham, and Mr. Holt appeared before the Select Committee on June 13th and 15th.

Finance.

The Receipts for the past year include the annual grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400) : annual subscriptions have produced £160, composition fees £16, the rent of tables at the Laboratory £34, the sale of specimens £205, and the admission to the tank-room £70 ; the total amounting, with lesser sums, to £2199.

The Vice-Presidents, Officers, and Council proposed by the Council for 1893—1894 are:

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Walsingham, F.R.S.
Lord Revelstoke.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. Alfred Newton, F.R.S.
Sir Henry Thompson.
Rev. Canon Norman, D.C.L., F.R.S.
Captain Wharton, R.N., F.R.S.

COUNCIL.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
Prof. W. A. Herdman, F.R.S.
Sir John Evans, K.C.B., D.C.L., F.R.S.
A. C. L. G. Günther, Esq. F.R.S.
Prof. A. C. Haddon.
Sydney J. Hickson, Esq., D.Sc.
Prof. W. C. McIntosh, F.R.S.
Lord Tweedmouth.
Prof. E. B. Poulton, F.R.S.
P. L. Sclater, Esq., F.R.S. (Sec. Zool. Soc.).
Adam Sedgwick, Esq., F.R S.
Prof. Charles Stewart, P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.—E. L. Beckwith, Esq.

Hon. Secretary.—G. Herbert Fowler, Esq., Ph.D.

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1893.* Cr.

Receipts.		£	s.	d.	£	s.	d.
To Balance from last year, being Cash in Bank and in hand less outstandings (General Fund and Bait Investigation Fund)					106	16	6
,, H. M. Treasury					1000	0	0
,, Fishmongers' Company					400	0	0
,, Donation, J. P. Thomasson, Esq.					250	0	8
,, Annual Subscriptions					160	12	0
,, Composition Fees and Donations					16	5	6
,, Rent of Tables	£34 0 0						
,, Sale of Specimens	205 16 9						
,, Sale of Journal	20 6 1						
		260	2	10			
,, Sale of Monograph		6	15	7			
,, Admission to Tank Room		70	0	10			
,, Interest on Investment		35	2	0			
					372	1	3
,, Balance forward, being amount overdrawn at Bankers less Cash in hand (General Fund and Bait Investigation Fund)					196	13	8
					£2502	9	7

Examined and found correct.

F. Jeffrey Bell,
S. E. Spring Rice,
Edwin Waterhouse,
C. Stewart, } *Auditors.*

Expenditure.		£	s.	d.	£	s.	d.
By Salaries and Wages:							
Director		205	0	0			
,, Allowance for Assistant		67	3	4			
Naturalist		250	0	0			
Mr. E. W. L. Holt, North Sea Investigation		200	0	0			
Mr. W. Garstang (Assistant Naturalist)		150	0	0			
Wages, Salaries of Clerk, &c.		350	17	0			
					1223	0	4
By Stationery, Office Printing, Postage, &c.					138	10	0
,, Printing and illustrating Journal					106	1	4
,, Purchase of Steam Launch					290	13	2
,, Sundry Expenses:							
Gas, Water, Coal, Oil, &c.	£110 14 5						
Coal and Water for Steam Launch	36 3 2						
		146	17	7			
Stocking Tanks, Feeding, &c.		72	6	5			
Glass, Chemicals, Apparatus, &c.	139 3 2						
Less Sales to table renters	12 3 2						
		127	0	0			
Maintenance and Renewals of Building, Boats, and Nets		123	2	10			
,, Rates and Taxes		26	10	6			
,, Boat Hire		33	15	6			
,, Travelling		57	8	1			
,, Library		45	14	3			
,, North Sea Investigation at Cleethorpes, Grimsby		90	13	1			
,, Immature Fish Investigation		20	0	0			
,, Labrador Investigation		0	16	6			
					744	4	9
					£2502	9	7

Investment held 31st May, 1893:
£900 Forth Bridge Railway 4% guaranteed Stock at 125...£1125 0 0

Director's Report.—No. II.

Some explanation is due to the members of the Association for the delay in the publication of the Journal, which in the ordinary course would have appeared in November, 1893. It is proposed for the future to issue the half-yearly parts in July and January, and accordingly the publication of the present number was deferred from November of last year to January, 1894. Unforeseen circumstances affecting myself have caused a further postponement, but the customary punctuality in the appearance of the Journal will be observed in the future.

One of the main objects of the Laboratory has been fulfilled since my last report (May, 1893) by the constant presence of zoologists in addition to the two naturalists on the staff. Their names are given below.

The field for investigation in marine botany and in the physiology of marine animals is at least as wide as that in marine zoology, yet neither a botanist nor a physiologist has made use of the resources of this Laboratory, where their work could be carried on with the minimum of trouble and inconvenience. A most interesting and important botanical problem, to mention one only which could well be studied at Plymouth, would be the nutrition and excretion of marine algæ, and the manner in which they affect the sea water they live in, under varying physical and chemical conditions. The physiology of marine animals, as far as it is known, has largely been the study of zoologists, who have made occasional observations on the living animals observed, and it is much to be desired that specially trained physiologists should apply modern methods to research on marine Invertebrata. By acquiring a quantity of well-established data for comparison with Vertebrates, the science would be made broader in its scope, and some questions of fundamental importance could be brought nearer to solution by the application of the methods of comparison. A subject which, from work already done, promises important results is the action of the various coloured and colourless circulatory fluids in the respiration of marine animals. There are a number of highly interesting questions connected with the chemistry of sea water on the one hand, and the influence of bacteria upon its composition on the other, which can only be properly studied in a well-fitted marine biological laboratory. Even the purely chemical side of this subject has so far hardly been touched upon, and next to nothing is known of the quantity and behaviour of the combined nitrogen in different sea waters.

What I wish to make clear is that the Laboratory is not devoted exclusively to the use of zoologists, and that the means for the pursuit of any branch of science as applied to the sea and its contents will readily be supplied, and those who will undertake the work heartily welcomed.

Repairs and alterations in the building concern chiefly the west block. The passages and staircase walls have been distempered and painted. The laboratory known as the physiological room, occupied at present by Mr. Garstang, is used for the purposes of the specimen department, but, if necessary, would serve, as it has done before, for physiological experiment. The new fittings include a slate-top table (seven feet by three feet) with a leaden sea-water supply pipe running along the wall behind it, and pierced for six vulcanite nozzles. A bench for microscope work, drawers, cupboards, and shelves have also been added. In the same room I have provided an earthenware sink, with several fresh-water jets, which is enclosed in a cupboard with a rising wooden front (like a sash window), and serving to darken the sink completely, while specimens are washing in a stream of water after treatment with reagents susceptible to the influence of light, as osmic acid, chromic acid, &c.

The old steam-launch, the "Firefly," has done good service in spite of her many and great disadvantages for our purposes. Since December last she has been finally laid up, and the eighteen-foot sailing-boat, the "Anton Dohrn," has been made good use of inside the Sound during the recent continuously stormy weather. The sea has been too high for work outside the Breakwater, but on calmer days a fast steam-tug, the "Lorna," is always at our disposal, on hire.

Notwithstanding the fact that the past winter has been one of the coldest known for fifty years in Devonshire, the condition of the fish in the aquarium has remained extremely good, and none have died as in former winters. The red mullet referred to in Mr. Cunningham's note have lived in the tanks since August last, and are all perfectly healthy. The whiting have been, and plaice and flounders still are spawning. The eggs of the spotted dog-fish, *Scyllium canicula,* which have been fertilized and laid in the tanks, have developed normally during the winter.

I have placed between the tanks a series of water-colour drawings of the permanent inhabitants, carefully copied from life by Miss A. Willis of Plymouth. The variety of the animals in each tank, and other obvious reasons, made it difficult to directly label each with its name; the pictures, however, supply the want to a large extent, and can often be examined more closely than the animal itself in order to help to confirm observations on colour, structure, &c.

These drawings were shown as part of an exhibit from the Association at the Cornwall County Fisheries Exhibition held at Truro in August, 1893. A complete set of nets actually used at the Plymouth Laboratory for natural history purposes was also contributed. The most successful and a very popular part of the exhibit was the collection of fishes (showing larval and post-larval development), brachyuran crustacea, and opisthobranchiate mollusca. The specimens were all collected by the Naturalists to the Association, and arranged for exhibition by Dr. Fowler.

The Exhibition is of more than passing interest, for it will have an important permanent outcome in the Cornwall County Fisheries School. The Exhibition has been the means of arousing public interest for the scheme initiated by Mr. E. W. Rashleigh of Kilmarth, a member of the Association, and his plans are now on the point of being realised. His results will, no doubt, be followed with great interest, and should have the full sympathy of the members of the Association. So far the County Council has given its approval and support, and the choice of a locality is at present under consideration.

The inquiry into the distribution of the anchovy in the Channel has been continued. The reward offered brought in less than twelve fish to the Laboratory from the end of October to the middle of December. Thus there is reason to believe that anchovies, like herring, pilchard, and mackerel, have in the past season been scarce in this part of the Channel. An attempt was made to obtain them with our own anchovy nets on the night following the capture of a few specimens three miles south of the Breakwater, but without success.

After numerous trials it has been found quite feasible to send most of the animals caught in dredge and tow-net alive to any part of the United Kingdom and Wales. Accordingly a new price-list has been prepared, giving a selection of the commonest and most interesting animals of each group, with two prices for each; one for the living animal, and the other, slightly higher, for the preserved specimen. By giving ample notice teachers and others can always rely on obtaining certain living animals on certain days, as we can secure them in advance when necessary and keep them alive until wanted.

EDWARD J. BLES.

March, 1894.

T. R. Riches, B.A.	May 1st—December 21st.
E. J. Allen, B.Sc.	June 1st.
E. W. MacBride, M.A.	June 8th—July 12th.
Prof. W. F. R. Weldon, M.A., F.R.S.	July 1st—August 8th.
F. W. Gamble, B.Sc.	August 7th—September 7th.
Florence Buchanan, B.Sc.	August 24th—October 4th.
E. T. Browne, B.Sc.	September 4th—October 7th.
W. T. Hughes	August 7th—August 15th.
S. J. Hickson, M.A., D.Sc.	December 9th—January 6th.
G. P. Bidder, M.A.	December 8th—February 28th.

Marine Biological Association of the United Kingdom.

Report of the Council, 1893-94.

The Council.

The Council has met on nine occasions during the past year for the transaction of the business of the Association. Of these the meeting on May 12th was held at the Plymouth Laboratory. The average attendance at these meetings has been six. No vacancy has occurred in the course of the year.

The Council has again to acknowledge the courtesy of the Royal Society in granting the use of its rooms for the various meetings of the Association.

By the death of Mr. John Bayly, of Plymouth, the Association has lost one of its first and most generous supporters, who had been a Governor almost from the commencement; and, by the death of Prof. A. Milnes Marshall, a member of the first Council of the Association in 1884.

The Plymouth Laboratory.

The Council is able to report satisfactorily of the condition of the building, fittings, and machinery at the Plymouth Laboratory, with the exception of some leakage in the large reservoirs, which will be repaired shortly. The Ejector, by which sea water is thrown up to the Laboratory reservoirs, and the rotary pumps by which the circulation is maintained, have lately been overhauled and placed in thorough repair.

The Boats.

It is greatly to be regretted that there is no immediate prospect of a satisfactory boat being obtained by the Association: the question is purely a financial one, and its solution is only to be found in the generosity of public companies or private individuals. It is impossible that a sea-going boat can be purchased out of income, so long as the revenue of the Association is so small. During the past year the work of collection has been largely carried out by means of hired vessels, a method both expensive and unsatisfactory. The little sailing boat "Anton Dohrn" is utilised whenever the weather permits, and is in good repair.

The Library.

The Library becomes annually more useful. Among the Fishery publications are included not only the official publications of the United Kingdom, of the United States, Canada, and Newfoundland; of Norway, Sweden, Denmark, Germany, the Netherlands, France, and Russia; but also the publications of local authorities and fishery societies at home and abroad. Among the results of various expeditions which are still in course of publication, may be mentioned the publications of the German "Plankton" Expedition, of H.H. the Prince of Monaco, of the Norwegian North Atlantic Expedition, and of the expedition of the Danish gunboat Hauch. Gifts and exchanges have been made during the past year of the publications of the Royal Societies of London and Edinburgh, the Zoological Society, the Royal Microscopical Society, the Academies of Copenhagen and Stockholm, the Harvard Museum, the Australian Museum, the Bergen Museum, the College of Science at Tokio, the Royal Society of Victoria, the Natural History Societies of Finland, Norway, the Netherlands, Boston (U.S.), and many others. To these Societies, and to the numerous donors of books and papers, the Council render the thanks of the Association.

In addition to such gifts and exchanges, the Library purchases all the most important periodicals which bear upon marine zoology.

The Museum and Exhibition Series.

The type-collection of the Plymouth fauna has been materially added to during the past year.

The series of specimens mounted for exhibition, to which reference was made in the last report of the Council, has been considerably increased, and has won great attention on the occasions on which it has been shown, viz. the meeting of the Museums Association in London, 1893, the soirée of the Royal Microscopical Society, 1894; the two soirées of the Royal Society, 1894; and the Cornwall Fisheries Exhibition, 1893.

At this last Exhibition, which was held with a view to the foundation of a Fisheries Technical School in Cornwall, the Association took a prominent part. Besides the exhibition of mounted specimens illustrating the rate of growth in food-fishes and the richness of the Plymouth fauna for scientific work, &c. &c., a complete set of a naturalist's equipment of dredges, trawls, and tow-nets was shown, and lectures were delivered by Mr. Cunningham on "The Natural History of Marketable Sea-Fishes," by Mr. Garstang on "Animal Life in our Seas and the Methods for its Investigation," and by the Hon. Secretary on the "Conditions for Successful Oyster Culture." A medal was awarded to the Association for its services to the Exhibition.

The Staff.

Through the generosity of the Worshipful Companies of Fishmongers and of Drapers, each of which has made a special donation of £105 for the purpose, the Council has been enabled to retain the services of Mr. Holt at Grimsby for a third year.

The Council regret that Mr. Garstang, desiring to prosecute original researches elsewhere, has not offered himself for re-election. As the post has been an annual one, the Council do not consider that the finances of the Association justify them in filling it up at present.

Scientific Investigations.

Both Mr. Cunningham and Mr. Holt have continued during the past year their inquiries into the various questions relating to the maturity of food-fish which were so prominent last year before the House of Commons Select Committee on Sea Fisheries, and upon which much information is still required. The value of the evidence adduced on these points by the officers of the Association has been acknowledged in the Report of this Committee.*

Mr. Cunningham has finally settled by direct experiment the much-debated question of the identity of the egg of the pilchard. He has been able to rear the larvæ of plaice, hatched and fertilized in the aquarium at Plymouth, to the age of thirty-seven days; no flat-fish larvæ have hitherto been reared in confinement from the ovum to this age, and this result is of great economic value.

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* "Your Committee have however, had an advantage over any previous fishery inquiry in the fact that they have had laid before them the statistics which have of recent years been collected by the Board of Trade, and the statistics compiled by the officers of the Scottish Fishery Board; and they have also had the evidence founded on the observations of the scientific experts employed by the Marine Biological Association, and by the Scottish Fishery Board. Indeed it may almost be said that this is the first fishery inquiry in which the more important complaints have been founded, not merely on the statements and the ideas of rival classes of fishermen, but upon facts and statistics."

Mr. Holt's valuable statistical observations on the fish landed at Grimsby have been continued. From his watching of the results of the newly opened Iceland fishery, on which he contributes a paper to the last number of the Journal, may be expected interesting light as to the effect of fishing on a virgin ground, with a direct bearing on the problems presented by the North Sea. The arrangement by which the Association contributes towards the expenses of the Cleethorpes Aquarium of the Marine Fisheries Society (Grimsby) in return for Mr. Holt's use of their Laboratory and tanks, is being continued for a second year.

Mr. Garstang reports that the following were the more interesting additions to the list of the Plymouth fauna during the past year:

Amphicodon amphipleurus, Haeckel.
Coryne vermicularis, Hincks.
Garveia nutans, Str. Wright.
Depastrum cyathiforme, M. Sars.
Fecampia erythrocephala, Giard.
Eupolia curta, Hubrecht.
Heteromysis formosa, Smith.
Erythrops elegans, G. O. Sars.
Mysidopsis gibbosa, G. O. Sars.
Leptomysis mediterranea, G. O. Sars.
Apseudes Latreilli, M. Edw.
Coryphella smaragdina, A. and H.
Doliolum tritonis, Herdm.
Thalia democratica-mucronata, Forskål.

A *Doris* and a remarkable *Tectibranch*, both of which are new to science, have not yet been described.

A number of interesting analyses of sea water have been made by Mr. Frank Hughes for the Association, and experiments on the changes produced in sea water in aquaria are being carried out by the Director.

Occupation of Tables.

The following naturalists have occupied tables in the Laboratory during the past twelve months:

E. J. Allen, B.Sc., University College, London (Development of Decapod Nervous System).
G. P. Bidder, B.A., Naples (Porifera).
E. T. Browne, B.A., University College, London (Medusæ).
Miss F. Buchanan, B.Sc., University College, London (Chætopoda).
F. W. Gamble, B.Sc., The Owens College, Manchester (Turbellaria).
S. J. Hickson, M.A., D.Sc., Cambridge (Development of Alcyonium).
W. T. Hughes, Birmingham (General Zoology).
E. W. MacBride, M.A., Cambridge (Development of Asterina).
T. H. Riches, M.A., Plymouth (Development of Nemertina).
T. C. Sumner, Royal College of Science, London (Nudibranchiata).
Prof. W. F. R. Weldon, F.R.S., University College, London (Variation of *Carcinus mœnas*).

Surgeon P. W. Bassett-Smith, R.N., Plymouth, and Mr. H. R. Battye, B.Sc., University College, London, have also made use of the Laboratory without formal occupation of a table.

The following papers, either wholly or in part the outcome of work done at the Plymouth Laboratory, or by members of the staff stationed elsewhere, have appeared in the publications of learned Societies and in scientific periodicals during the past year; in addition to those which have been published in the Journal:

Allen, E. J.—*On the Central Nervous System of Crustacea*, Quart. Journ. Micr. Sci.

Cunningham, J. T., and C. A. MacMunn.—*On the Coloration of the Skins of Fishes, especially Pleuronectidæ*, Phil. Trans. Roy. Soc., clxxxiv, B., 765.

Garstang, W.—*On the Relations of Hesse's Doto uncinata to the genus Hancockia*, Conchologist, ii, 110.

Garstang, W.—*Note on Salensky's account of the development of the Stigmata in Pyrosoma*, Tr. Liverpool Biol. Soc., vii. 245.

Garstang, W.—*On someBipinnariæ from the English Channel*, Quart. Journ. Micr. Sci., xxxv, 451.

Garstang, W.—*Preliminary note on a new theory of the Phylogeny of the Chordata*, Zool. Anz. 1894.

Holt, E. W. L.—*Studies in Teleostean Morphology, from the Marine Laboratory, Cleethorpes*, Proc. Zool. Soc., 1894.

MacBride, E. W.—*The Organogeny of Asterina gibbosa*, Proc. Roy. Soc., liv, 431.

Weldon, W. F. R. W.—*Certain Correlated Variations in Carcinus mœnas*, Proc. Roy. Soc., liv, 318.

Donations and Receipts.

The Receipts for the past year include the annual grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400); a special donation of £105 each from the Worshipful Companies of Fishmongers and of Drapers; annual subscriptions have produced £178, composition fees £15 15s., the rent of tables in the Laboratory £36, the sale of specimens £197, the admission to the aquarium £77; the total amounting, with lesser sums, to £2172. The statement of Receipts and Expenditure will be found below.

The Vice-Presidents, Officers, and Council proposed by the Council for 1894–95 are—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Walsingham, F.R.S.
Lord Revelstoke.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. Alfred Newton, F.R.S.
Sir Henry Thompson.
Rev. Canon Norman, D.C.L., F.R.S.
Captain Wharton, R.N., F.R.S.

COUNCIL.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, Sec.R.M.S.
Prof. W. A. Herdman, F.R.S.
Sir John Evans, K.C.B., D.C.L., F.R.S.
A. C. L. G. Günther, Esq., F.R.S.
Prof. A. C. Haddon.
Prof. S. J. Hickson, D.Sc.
Prof. W. C. McIntosh, F.R.S.
Lord Tweedmouth.
D. H. Scott, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S. (Sec. Zool. Soc.).
Adam Sedgwick, Esq., F.R.S.
Prof. Charles Stewart, P.L.S.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.—E. L. Beckwith, Esq.

Hon. Secretary.—G. Herbert Fowler, Esq., Ph.D.

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1894.* Cr.

Receipts.		£	s.	d.	£	s.	d.
To H. M. Treasury					1000	0	0
,, Fishmongers' Company					400	0	0
,, Special Donations:							
Drapers' Company		105	0	0			
Fishmongers' Company		105	0	0			
					210	0	0
,, Annual Subscriptions					178	10	0
,, Composition Fees and Donations					15	15	0
,, Rent of Tables	£36 16 3						
,, Sale of Specimens	197 9 1						
,, Sale of Journal	14 1 4						
		248	6	8			
,, Sale of Monograph		6	10	0			
,, Admission to Tank Room		77	16	6			
,, Interest on Investment		34	19	10			
					367	13	0
,, Investment Sold: £230 Forth Bridge Railway 4% guaranteed Stock					303	7	3
					£2475	5	3

Examined and found correct.

F. Jeffrey Bell,
Sydney J. Hickson,
Edwin Waterhouse,
Stephen E Spring Rice,
} *Auditors*

Expenditure.		£	s.	d.	£	s.	d.
By Balance from last year, being amount overdrawn at Bankers, less Cash in hand (General Fund and Bait Instigation Fund)					196	13	8
,, Salaries and Wages:							
Director		200	0	0			
,, Allowance for Assistant		80	0	0			
Mr. J. T. Cunningham		250	0	0			
Mr. E. W. L. Holt, North Sea Investigation		200	0	0			
Mr. W. Garstang (Assistant Naturalist)		175	0	0			
Wages		358	7	0			
					1263	7	0
,, Stationery, Office Printing, Postage, &c.					168	3	6
,, Printing and illustrating Journal, &c.					85	14	9
,, Sundry Expenses:							
Gas, Water, Coal, Oil, &c.	£107 10 5						
Coal and Water for Steam Launch	22 5 3						
		129	15	8			
Stocking Tanks, Feeding, &c.		90	17	4			
Glass, Chemicals, Apparatus, &c.	131 13 5						
Less Sales to table renters	8 4 3						
		123	9	2			
Maintenance and Renewal of Building, Boats, and Nets		131	13	0			
,, Rates and Taxes		34	12	3			
,, Boat Hire		41	8	10			
,, Travelling		42	5	5			
,, Expenses of Exhibition of Specimens		59	7	10			
,, Library		21	3	4			
,, North Sea Investigation at Cleethorpes, Grimsby		76	12	1			
					751	4	11
,, Balance forward, being Cash in Bank and in hand (General Fund and Bait Investigation Fund)					10	1	5
					£2475	5	3

Investment held 31st May, 1894:
£670 Forth Bridge Railway 4% Guaranteed Stock at 125...£837 10 0

Director's Report.—No. III.

Since the publication of the last number of this Journal six months have elapsed, and in so short a time no great development in an institution of the nature of this Laboratory can be expected. But the Laboratory has not yet reached its teens, and at the present early age a perceptible amount of growth and improvement should show itself from year to year.

The number of gentlemen who have carried on researches here has shown no diminution, but has not sensibly increased. In one respect the list given below may be regarded as showing an improvement;—it is not exclusively formed of zoologists. Mr. Darnell-Smith, a chemist and naturalist, has been good enough to take up an investigation I suggested in my last Report, and his results concerning the action of Algæ on the sea-water in which they live are most interesting. They will be published in the next number of this Journal. It is to be hoped that the study of animal physiology will soon be undertaken here once more. The number of marine animals is very great, which, by reason of various degrees of transparency, allow their internal anatomy and the behaviour of internal organs in activity or in repose, under normal and abnormal conditions, to be seen during life. Many of such animals are highly convenient for microscopic examination, and there is no doubt that such objects are of great assistance in studying the functions of living digestive, secretory, excretory, and, in fact, all the cells of the different systems of organs. Work of this kind has already been done on fresh-water and marine animals, but the immense variety of the transparent animals in the sea seems to afford special advantages. Material of this nature is constantly being brought into the Laboratory.

For some time past no scientific men from abroad have visited the Laboratory for any length of time. With all due respect to the "big brother" at Naples, I would like to remind those whose eye this may meet that there is a time of the year when Naples is hardly a desirable place of residence, and that Plymouth is just at this time one of the most attractive spots in England. The beautiful counties of Devon and Cornwall are on either hand, Dartmoor is behind our back, and we look out upon the English Channel with its mingled northern and southern forms of life. There are, I am sure, enthusiastic naturalists abroad who would like to spend their summer holidays at the work which can so comfortably be done at this Laboratory. They would find, if they will but try the experiment, that an English summer has charms equal to those of an Italian winter and spring, and what is not unimportant to most scientific men, that the advantages of cheap lodging and living are not confined to the Continent.

Mr. Garstang, who has for some years occupied different posts at the Laboratory, has kindly consented to give a summary of his notes on the seasonal variations of the local fauna, and the data in this number of the Journal will to a certain extent be an indication of what may be expected to occur during the summer.

Mr. Garstang left the service of the Association on May 30th. He has since paid a visit to the Laboratory, and collected fresh material, and it is to be hoped that he will often be tempted to revisit the spots he has studied so closely and knows so well.

The specimen trade has since his departure been in my hands. I am glad to report that it is increasing rapidly; to such an extent, in fact, that it is interfering with a higher phase of my duties, the investigations which have been slowly growing under my hands. The study of the influence of external physical conditions on the character and distribution of pelagic life (Plankton) is full of charms on account of its constant variety, and it is this also which makes it a particularly time-devouring study. I have found the complicated conditions of the currents in Plymouth Sound make the solution of the causes of the movements of Plankton practically hopeless as regards this locality. But comparative observations on the character and quantity of Plankton at different distances from the land, until we reach the Channel current, have given some striking results. There is at certain times a great difference in the relative quantity, and correlated with this a proportional difference in the quantity, of mackerel in the Sound and outside it. This subject will, I feel sure, yield most interesting results before long.

The boats at our disposal are by no means capable of doing all that could be done to support the functional activity of the Laboratory. The small steam-tug "Lorna," which we hire, can only leave the Sound on calm days. Our small sailing boat, the "Auton Dohon," has done excellent service, but is not capable of covering long distances within a reasonable time. I have been able to increase her efficiency materially by the addition of a centre-board to haul up in shallow water or when running before the wind, and to lower when sailing close to the wind. She can now very often do her day's work with a considerable gain in time, bringing up material quicker, and hence fresher and earlier in the day.

The export of living animals is proving more and more successful as experience is gained, and it is increasing in importance. Members of the Association living inland can generally obtain a supply of sea-water by rail once or twice a year, and with a few simple precautions it can be used to keep alive marine animals and plants sent from Plymouth, some of which,—sea-anemones, for instance,—will live for years; others could be replaced at intervals as they die. Larvæ of Crustacea could be watched as they pass through their metamorphoses, for Aminifera could be kept alive and their growth observed, and no doubt many new and interesting facts would be collected by means of a little application and study of such animals in small aquaria.

I have been able to remedy a serious defect in the arrangements for supplying sea-water to the Laboratory. During the month of August it was noticed that the water pumped up was not fit to use, and it was not allowed to pass into the circulation. It had been proved a short time previously that the water obtained in the same way was quite as good as water from the Channel for rearing Foraminifera. The abnormal condition persisted for a time and then disappeared and reappeared, until at last a dead fish was pumped, and then a large piece of fucus, and so on.

Appearances pointed to a defect in the supply pipe which runs out from the base of the rocks below the Laboratory for a distance of fifty yards and lies on the sea-bottom. A diver went down to inspect and soon reported that the iron pipe was broken across near the outer end, and that the near end was buried in mud. I decided to repair the pipe at once, and as the weather permitted, it was put right in three days, the broken length of pipe removed, the lengths of the detached portion taken off one by one and connected with the shore end, and on the upturned end of the last length the large rose was replaced. Still for three weeks the water pumped up had something unusual about its smell and appearance, and at last the dead body of an eel, four feet long, which must have been shut in the pipe by the diver, came up. Since this time (20th September) the water has come up clear and fresh, and a state of affairs which may have lasted a couple of years or more, has come to an end. The probability is that the anchor of some ship caught the pipe and fractured it; the difficulty is to explain the presence of a vessel large enough to do the damage so close to the shore (thirty yards). Maybe the great storm of March, 1891, is to to blame for this; the wind blew off-shore for some time, and a vessel so close to the rocks would not have been in immediate danger.

This number of the Journal consists almost entirely of papers on the results of work done at this Laboratory or at the Cleethorpes Laboratory by Mr. Holt. I need say nothing of what my colleagues have done, but I should like to add that the short abstract given by Mr. Allen gives the main points only of a series of papers published elsewhere, detailing the outcome of more than a year of laborious research which Mr. Allen spent at the Laboratory. The original papers are illustrated with plates containing a number of complicated figures, showing the course of a large number of the nerves in the lobster and other histological details.

This Journal has for some time been devoted almost entirely to the publication of work done by the naturalists of the Association, and private workers in the Laboratory. It is now proposed to resume the insertion of articles on the subjects with which we are concerned, abstracted from foreign publications, or contributed by colonial, American, or continental workers in the same fields. Many of H.B.M. Consuls may have useful and interesting information on the many sides of the subject of sea fishes and sea fisheries, oyster-culture, fish-hatching, and breeding. I beg to invite the gentlemen abroad, who are employed on similar work to ours, to send either early copies of their publications, or to communicate the main results of their work for the benefit of our members and other readers.

EDWARD J. BLES, *Director.*

October, 1894.

E. J. Allen	Governors' and Founders' tables	1st June, 1893—9th August, 1894.
E. A. Minchin	Oxford University	13th March, 1894—2nd April, 1894.
J. C. Sumner	Rented a table	9th April, 1894—30th April, 1894.
	Mercers' Company	1st May, 1894—1st June, 1894.
J. J. Lister	Cambridge University	1st June, 1894—30th June, 1894.
	Rented a table	1st July, 1894—1st August, 1894.
M. D. Hill	British Association	6th July, 1894—28th July, 1894.
E. T. Browne	Rented a table	13th July, 1894—21st July, 1894.
G. P. Darnell-Smith	,, ,,	31st July, 1894—27th August, 1894.
G. P. Bidder	,, ,,	15th Sept., 1894—29th Sept., 1894.
W. Garstang		27th Sept., 1894—4th Oct., 1894.

LIST

OF

Governors, Founders, and Members.

OCTOBER, 1894.

I.—Governors.

The British Association for the Advancement of Science, 22, *Albemarle Street, W.*	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£500
The Worshipful Company of Fishmongers, *London Bridge*	£2000
The University of Oxford	£500
Bayly, Robert, *Torr Grove, Plymouth*	£1000
Bayly, John (late), *Seven Trees, Plymouth*	£600

II. Founders.

* Member of Council. † Vice-President. ‡ President.

1884	The Corporation of the City of London	£210
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£210
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£315
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£100
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£250
1884	The Zoological Society, 3, *Hanover Square, W.*	£100
1884	Bulteel, Thos., *Radford, Plymouth*	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1888	Bury, Henry, B.A., *Trinity College, Cambridge*	£100
1884	Crisp, Frank, LL.B., B.A., V.P. and Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C*	£100
1884	Daubeny, Captain Giles A., 30, *Cornwallis Crescent, Clifton, Bristol*	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Shipton, Yorkshire*	£100
1884	Gassiott, John P., *The Culvers, Carshalton, Surrey*	£100
‡*1884	Lankester, Prof. E. Ray, F.R.S., 2, *Bradmore Road, Oxford*	£100
1885	Derby, The Rt. Hon. the late Earl of, K.G., 33, St. James's Square, S.W.	£100

1884	Lister, S. Cunliffe, *Swinton Park, Masham, Yorkshire*	£100
†1884	Lubbock, The Rt. Hon. Sir John, Bart., M.P., F.R.S., *High Elms, Bromley, Kent*	£100
*1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
†1889	Revelstoke, Lord, *Membland, Yealmpton, S. Devon*	£100
1890	Riches, T. H., B.A., *Inglenook, Yelverton, S. Devon*	£100
1884	Romanes, G. J., LL.D., F.R.S. (late), *St. Aldate's, Oxford*	£100
†1884	Thomasson, John P., M.P., *Woodside, near Bolton*	£350
†1889	Thompson, Sir Henry, 35, *Wimpole Street, W.*	£100
*1887	Weldon, Prof. W. F. R., F.R.S., 30A, *Wimpole Street, W.*	£100
1884	Worthington, James (late), *Sale Hall, Sale, Manchester*	£100

III.—Members.

ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

1886	Adlard, R. E., 22½, *Bartholomew Close, London, E.C.*	*ann*
1884	Alger, W. H., *Manor House, Stoke, Devonport*	*C.*
†1884	Allman, Prof. G. J., F.R.S., *Ardmore, Parkstone, Dorset*	£20
1889	Anderson, Dr. John, 71, *Harrington Gardens, S.W.*	*C.*
†1884	Argyll, The Duke of, K.G., *Argyll Lodge, Kensington, W.*	*C.*
1885	Armstrong, Lord, C.B., F.R.S., *Crag Side, Rothbury*	*C.*
1893	Ascroft, R. L., 11, *Park Street, Lytham, Lancs.*	*ann.*
1884	Ashworth, J. W., M.R.C.S., 40, *Benyon Road, Kingsland, N.*	*ann.*
1892	Assheton, R., *Birnam, Cambridge*	*ann.*
1890	Badger, A. B., B.A., *Glenleigh, Oakfield Road, Balsall Heath, Birmingham*	*ann.*
1884	Bailey, Charles, F.L.S., *Ashfield, College Road, Whalley Range, Manchester*	*ann.*
1893	Bailey, W. E., *Porth Enys Museum, Penzance*	*C.*
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	*C.*
1888	Balkwill, F. H., 3, *Princess Square, Plymouth*	*ann.*
1893	Bassett-Smith, P. W., Surgeon, R.N., *Royal Marine Barracks, Stonehouse, Plymouth*	*ann.*
1884	Bateson, Wm., *St. John's College, Cambridge*	*ann.*
1884	Bayliss, W. Maddock, B.Sc., *St. Cuthbert's, Hampstead Heath, N.W.*	*ann.*
1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1884	Beaumont, W. J., 9, *New Square, Cambridge*	*ann.*
1885	Beck, Conrad, 68, *Cornhill, E.C.*	*C.*
*1889	Beckwith, E. L., *The Knoll, Eastbourne*	*ann.*
1887	Beddard, F. E., *Zoological Society's Gardens, Regent's Park, N.W.*	*ann.*
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	*C.*
*1884	Bell, Prof. F. Jeffrey, 5, *Radnor Place, Gloucester Square, W.*	*ann.*
1887	Berrington, A. D., *Board of Trade, Whitehall, S.W.*	*ann.*
1890	Bidder, George, B.A., *Parker's Hotel, Napoli, Italy*	*C.*

1885	Bignell, Geo. Carter, M.E.S., 7, *Clarence Place, Stonehouse, Plymouth*	*ann.*
†1885	Birkbeck, Sir Edward, Bart., M.P., 10, *Charles Street, Berkeley Square, W.*	*ann.*
1893	Bles, A. J. S., *Palm House, Higher Broughton, Manchester*	*ann.*
1893	Bles, D. S., J.P., *Westbourne, Kersal, Manchester*	*ann.*
1894	Bles, M. S., J.P., *The Beeches, Broughton Park, Manchester*	*ann.*
1889	Bolitho, T. B., M.P., *Trewidden, Penzance*	*ann.*
1884	Bompas, G. C., 4, *Gt. Winchester Street, E.C.*	*ann.*
1884	Bossey, Francis, M.D., *Mayfield, Redhill, Surrey*	*ann.*
1884	Bostock, E., *Stone, Staffordshire*	*ann.*
1890	Bourne, Prof. A. G., *The Presidency College, Madras*	*ann.*
1884	Bourne, Gilbert C., *New College, Oxford*	*ann.*
1884	Bradford, J. Rose, B.Sc., *Physiological Laboratory, University College, W.C.*	*ann.*
1886	Brent, Francis, F.S.A., 6, *Tothill Avenue, Plymouth*	*ann.*
1890	Brindley, H. H., B.A., *St. John's College, Cambridge*	*ann.*
1886	Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey*	*C.*
1884	Brown, Arthur W. W., 6, *Sussex Square, W.*	*C.*
1893	Browne, Edward T., 141, *Uxbridge Road, N.W.*	*ann.*
1893	Buchanan, Miss Florence, *University College, London, W.C.*	*ann.*
1884	Buckton, G. B., *Weycombe, Haslemere*	*ann.*
1886	Bullar, Miss Anna K., *Bassett Wood, Southampton*	*ann.*
1887	Burd, J. S., *Cresswell, Higher Compton, Plymouth*	*ann.*
1889	Burnard, Robert, 3, *Hillsborough, Plymouth*	*ann.*
1884	Caine, H. T.	*C.*
1884	Caine, W. S., M.P., 132 and 133, *Palace Chambers, Bridge Street, S.W.*	£21
1887	Caldwell, W. H., 12, *Harvey Road, Cambridge*	*C.*
1887	Carter, James, F.G.S., 30, *Petty Cury, Cambridge*	*ann.*
†1884	Chamberlain, Rt. Hon. J., M.P., 40, *Princes Gardens, S.W.*	*ann.*
1884	Chapman, Edward, *Magdalen College, Oxford*	*ann.*
1884	Christy, Thomas Howard, *Malvern House, Sydenham*	*ann.*
1887	Clarke, Rt. Hon. Sir E., Q.C., M.P., 5, *Essex Court, Temple, E.C.*	£25
1884	Clay, Dr. R. H., *Windsor Villas, Plymouth*	*ann.*
1885	Clerk, Major-Gen. H., F.R.S., 40, *St. Ermin's Mansions, Caxton Street, S.W.*	£21
1886	Coates and Co., *Southside Street, Plymouth*	*C.*
1885	Collier Bros., *Old Town Street, Plymouth*	*C.*
1890	Cook, C. H., M.A., *Elmlea, South Stoke, Reading*	*ann.*
1891	Cornish, T. H., 4, *Clarence Place, Penzance*	*ann.*
1889	Crossman, Major-General Sir William, K.C.M.G., M.P., *Cheswick, Northumberland*	*ann.*
1885	Darwin, Francis, F.R.S., *Wychfield, Cambridge*	*C.*
1885	Darwin, W. E., *Ridgemount, Bassett, Southampton*	£20
1889	Davies, H. R., *Treborth, Bangor*	*ann.*
1888	Daw, R. Harvey, *Marsh Mills, Plympton, S. Devon*	*ann.*
1889	Deacon, J. Barrington, 11, *Osborne Place, Plymouth*	*ann.*
1885	Deby, Julien, C.E., 31, *Belsize Avenue, N.W.*	*ann.*
1885	Dendy, Arthur, D.Sc., *Canterbury College, Christ Church, New Zealand*	*ann.*

1884	Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.*	*C.*
1885	Dixey, F. A., M.A.Oxon., *Wadham College, Oxford*	£26 5*s. and ann.*
1890	Driesch, Hans, Ph.D., *Zürich, Switzerland*	*C.*
†1889	Ducie, the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.*	£40 15*s.*
1884	Dunning, J. W., 4, *Talbot Square, W.*	£26 5*s.*
1885	Durham, A. E., *Christ's College, Cambridge*	*C.*
*1884	Dyer, W. T. Thiselton, M.A., C.M.G., F.R.S., *Director of the Royal Gardens, Kew*	*C.*
1887	Ebrington, Viscount, *Castle Hill, North Devon*	*ann.*
1893	Edward, Stanley, F.Z.S., *Kidbrook Lodge, Blackheath, S.E.*	*ann.*
1891	Ellis, Hon. Evelyn, *Rosenais, Datchet, Windsor*	*C.*
1893	Enys, John Davies, *Enys, Penryn, Cornwall*	*ann.*
*1884	Evans, Sir John, D.C.L., Treas. R. Soc., *Nash Mills, Hemel Hempstead*	£20
*1885	Ewart, Prof. J. Cossar, M.D., *University, Edinburgh*	£25
1884	Fayrer, Sir Joseph, M.D., K.C.S.I., F.R.S., 53, *Wimpole Street, W.*	*ann.*
1894	Ferrier, David, M.A., M.D., F.R.S., 34, *Cavendish Square, W.*	*ann.*
1884	Fison, Frederick W., *Greenholme, Burley in Wharfedale, Leeds*	*C.*
*†1884	Flower, Sir W. H., C.B., F.R.S., Director of the British Museum of Natural History, *Cromwell Road, S.W.*	*C.*
*1885	Fowler, G. Herbert, B.A., Ph.D., 12, *South Square, Gray's Inn, W.C.*	*ann.*
1884	Fox, George H., *Dolvean, Falmouth*	*ann.*
1889	Fraser, James, *Tregarthyn, Eton Avenue, N.W.*	*ann.*
1889	Freake, Sir Thomas S., *Warfleet, Dartmouth*	*ann.*
1886	Freeman, F. F., *Abbotsfield, Tavistock, S. Devon*	*C.*
1884	Fry, George, F.L.S., *Focklesbrook, Chobham, Surrey*	£21
1884	Fryer, Charles E., *Board of Trade, S.W.*	*ann.*
1892	Galton, F., F.R.S., 42, *Rutland Gate, S.W.*	*ann.*
1884	Galton, J. C., M.A., F.L.S., *New University Club, St. James's Street, W.*	*ann.*
1885	Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*	*C.*
1885	Gaskell, E. H., *North Hill, Highgate, N.*	*C.*
1893	Gatty, Charles Henry, LL.D., F.L.S., *Felbridge Place, East Grinstead*	*C.*
1884	Gibson, Ernest, F.Z.S., *Buenos Ayres*	*ann.*
1885	Glennie, W. R., *Berkeley Lodge, Wimbledon*	*ann.*
1884	Gonne, William	£26 5*s.*
1885	Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey*	*ann.*
1885	Gotch, Prof. F., F.R.S., 11, *Prince's Park Terrace, Liverpool*	*ann.*
1888	Goulding, F. H., *George Street, Plymouth*	*C.*
1884	Grove, E., *Norlington, Preston, Brighton*	*ann.*
1884	Groves, J. W., *Ermitage, Tunbridge Wells*	*ann.*
*1884	Günther, Dr. Albert, F.R.S., *Natural History Museum, Cromwell Road, S.W.*	*ann.*
*1884	Haddon, Prof. Alfred C., M.A., *Innisfail Hill Road, Cambridge*	*ann.*
1884	Halliburton, Prof. W. D., M.D., B.Sc., *King's College, Strand, W.C.*	*ann.*
1884	Hannah, Robert, 82, *Addison Road, Kensington, W.*	*C.*

1885	Harker, Allen, F.L.S., *Royal Agricultural College, Cirencester*	*ann.*
1885	Harmer, S. F., *King's College, Cambridge*	*C.*
1889	Harvey, T. H., *Cattedown, Plymouth*	*ann.*
1888	Haselwood, J. E., 3, *Lennox Place, Brighton*	*C.*
1884	Haslam, Miss E. Rosa, *Ravenswood, Bolton*	£20
1884	Hayne, C. Seale, M.P., 6, *Upper Belgrave Street, S.W.*	*ann.*
1884	Head, J. Merrick, F.R.G.S., J.P., *Ardverness, Reigate*	*ann.*
1884	Heape, Walter, *St. Mary's, Trumpington, Cambridge*	*C.*
1887	Heath, Miss A., 24, *George Street, Plymouth*	*ann.*
1884	Herdman, Prof. W. A., F.R.S., *University College, Liverpool*	*ann.*
1884	Herschel, J., Col. R.E., F.R.S., *Observatory House, Slough, Berks*	*C.*
1884	Heywood, James, F.R.S., 26, *Palace Gardens, W.*	*C.*
1889	Heywood, Mrs. E. S., *Light Oaks, Manchester*	*C.*
*1884	Hickson, Prof. Sydney J., M.A., D.Sc., *Downing College, Cambrige*	*ann.*
1884	Holdsworth, E. W. H., F.L.S., F.Z.S., *South Town, Dartmouth*	*ann.*
1893	Holt, Mrs. Vesey W., 104, *Elm Park Gardens, S.W.*	*ann.*
1894	Holt, Vesey G. M., F.Z.S., 17, *Whitehall Place, S.W.*	*ann.*
1889	Howell, Mrs. F. Bullar, *Ethy, Lostwithiel*	*ann.*
1887	Howes, Prof. G. Bond, F.L.S., *Science and Art Department, South Kensington*	*ann.*
1884	Hudleston, W. H., M.A., F.R.S., 8, *Stanhope Gardens, South Kensington, S.W.*	*ann.*
1885	Hurst, C. Herbert, Ph.D., *Owens College, Manchester*	*C.*
1884	Huxley, Rt. Hon. Prof. T. H., LL.D., F.R.S., *Hodeslea, Eastbourne*	£31

1891	Indian Museum, Calcutta, 65, *Cornhill*	*ann.*
1888	Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth*	*ann.*

1885	Jackson, W. Hatchett, M.A., F.L.S.. *Keble College, Oxford*	*ann.*
1893	Jago, Edward, *Menheniot, Cornwall*	*ann.*
1887	Jago-Trelawny, Major-Gen., F.R.G.S., *Coldrenick, Liskeard*	*C.*
1885	James, C. H., *Ingleside, Mutley, Plymouth*	*ann.*
1890	Jenkins, William, *Ocean Collieries, Treorgy, Glamorganshire*	*ann.*
1890	Johnson, Prof. T., B.Sc., F.L.S., *Royal College of Science, Dublin*	*ann.*
1890	Jones, W. V., 49, *George Street, Plymouth*	*ann.*
1892	Joshua, Mrs., 57, *Cadogan Square, S.W.*	*ann.*
1894	Justen, F. W., F.Z.S. (c/o Dulau and Co., 37, *Soho Square, W.*)	*ann.*

1884	Kellock, W. B., F.L.S., F.R.C.S., 94, *Stamford Hill, N.*	*ann.*
1884	Kent, A. F. S., *Physiological Laboratory, St. Thomas's Hospital, S.W.*	*ann.*

1885	Langley, J. N., F.R.S., *Trinity College, Cambridge*	*C.*
1888	Latter, O. H., *Charterhouse, Godalming, Surrey*	*ann.*
1885	Lea, A. S., M.A., *Caius College, Cambridge*	*ann.*
1884	Lewis, George, 88, *Portland Place, W.*	*ann.*
1888	Lloyd, Fred. H., 5, *Gertrude Terrace, Exmouth*	*ann.*
1884	London, The Lord Bishop of, *The Palace, Fulham, S.W.*	*ann.*
1888	Lopes, The Rt. Hon. Sir Massey, Bart., *Maristowe, Roborough, South Devon*	*ann.*

1885	Macalister, Prof. A., F.R.S., *St. John's College, Cambridge*	*ann.*
1884	Mackrell, John, *High Trees, Clapham Common, S.W.*	*C.*

1886	MacMunn, Charles A., *Oak Leigh, Wolverhampton*	*ann.*
1889	Makovski, Stanislaus, *Fairlawn, Red Hill*	*ann.*
1885	Marr, J. E., M.A., *St. John's College, Cambridge*	*C.*
1884	Mason, Philip Brookes, *Burton-on-Trent*	*ann.*
1884	McAndrew, James J., *Lukesland, Ivy Bridge, South Devon*	*ann.*
1884	McIntosh, Prof. W. C., F.R.S., 2, *Abbotsford Crescent, St. Andrews, N.B.*	*C.*
1884	Michael, Albert D., *Cadogan Mansions, Sloane Square, S.W.*	*C.*
1885	Mitchell, P. Chalmers, B.A., *Charing Cross Hospital, London*	*ann.*
1885	Mocatta, F. H., 9, *Connaught Place, W.*	*C.*
1886	Mond, Ludwig, 20, *Avenue Road, Regent's Park, N.W.*	*C.*
1884	Morgan, Prof. C. Lloyd, *University College, Bristol*	*ann.*
1891	Morgans, Thomas, *The Guildhall, Bristol*	*ann.*
†1889	Morley, Earl of, 31, *Prince's Gardens, S.W.*	*ann.*
1885	Morris, John, 13, *Park Street, Grosvenor Square, W.*	£21
1885	Morrison, Alfred, 16, *Carlton House Terrace*	£52 10*s.*
†1884	Newton, Prof. Alfred, M.A., F.R.S., *Magdalene College, Cambridge*	£20
†1884	Norman, Rev. Canon, M.A., D.C.L., F.R.S., *Burnmoor Rectory, Fence Houses, Durham*	*ann.*
1885	Oliver, Prof. F. W., *Royal Gardens, Kew*	*ann.*
1884	Ommanney, Admiral Sir Erasmus, K.C.B., F.R.S., 29, *Connaught Square, W.*	*ann.*
1885	Paget, Sir James, Bart., F.R.S., 5, *Park Place, W.*	*C.*
1884	Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham*	*ann.*
1891	Pass, A. C., 15, *Upper Belgrave Road, Durdham Down, Bristol*	*ann.*
1888	Peek, Sir Henry W., Bart., F.Z.S., *Wimbledon House, Wimbledon*	*C.*
1888	Pennsylvania, University of, *Philadelphia, U.S.A.*	*ann.*
1885	Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square, W.*	*C.*
1887	Phipson, Mrs., *Cumballa Hill, Bombay*	*ann.*
1892	Pearce, Sir W. G., Bart., M.P., 113, *Cannon Street, E.C.*	*ann.*
1885	Pochin, H. D., *Bodnant Hall, Eglwysbach, Denbighshire*	*C.*
1886	Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.*	*ann.*
1885	Pritchard, Prof. Urban, 26, *Wimpole Street, W.*	*ann*
1884	Pye-Smith, P. H., M.D., 48, *Brook Street, W.*	*C.*
1893	Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks*	*ann.*
1884	Radford, Daniel, *Mount Tavy, Tavistock*	*ann.*
1884	Ralli, Mrs. Stephen, *Cleveland House, Clapham Park*	£30
1885	Ransom, W. B., *Trinity College, Cambridge*	*C.*
1893	Rashleigh, E. W., *Kilmarth, Par Station, Cornwall*	*ann.*
1888	Rawlings, Edward, *Richmond House, Wimbledon Common*	*ann.*
1887	Riley, W., *Newcastle House, Bridgend, Glamorganshire*	*ann.*
1892	Robinson, Miss M., *University College, London, W.C.*	*ann.*
1894	Rodd, F. R., *Trebartha Hall, Launceston, Cornwall*	*ann.*
1884	Rowe, J. Brooking, F.S.A., F.L.S., *Mulgrave Street, Plymouth*	*ann.*

1892 Rüffer, M. A., M.D., 19, *Iddesleigh Mansions, S.W.* .... *ann.*
1885 Ruscoe, John, *Albion Works, Henry Street, Hyde, near Manchester*... *ann.*

1889 Sanford, W. A., *Nynehead Court, Wellington, Somerset*.................. *ann.*
1884 Schäfer, Prof. E. A., F.R.S., *University College, Gower Street, W.C.*.. *ann.*
1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin*............ *ann.*
*1884 Sclater, P. L., F.R.S., Sec. Zool. Soc., 3, *Hanover Square, W.*......... *ann.*
1884 Sclater, W. L., *Eton College, Windsor* .... *ann.*
1885 Scott, D. H., M.A., Ph.D., F.R.S., *Old Palace, Richmond, Surrey*... *C.*
*1884 Sedgwick, A., M.A., F.R.S., *Trinity College, Cambridge* .... *C.*
1888 Serpell, E. W., 19, *Hill Park Crescent, Plymouth* £50
1885 Sheldon, Miss Lilian, *Oldhall, Newnham College, Cambridge* .... *ann.*
1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* .... *C.*
1886 Shore, T. W., M.D., *The Warden's House, St. Bartholomew's Hospital, E.C.* .... *ann.*
1894 Simons, Carl W., 6, *Konigstrasse, Dusseldorf, Germany* .... *ann.*
1885 Sinclair, F. G., *New Museums, Cambridge* .... *C.*
1891 Sinclair, William F., *Bombay Civil Service, Bombay*...................... *C.*
1884 Skinners, the Worshipful Company of, *Skinners' Hall, E.C.* £42
1889 Slade, Lieut. E. J. Warre, *St. Margaret's, Reigate*......................... *C.*
1884 Sladen, W. Percy, Sec. Linn. Soc., 13, *Hyde Park Gate, S.W.*......... *ann.*
1893 Sorby, H. C., LL.D., F.R.S., *Broomfield, Sheffield*.......................... *ann.*
1884 Spencer, J., 121, *Lewisham Road, Lewisham, S.E.*........................ *ann.*
1888 Spencer, Prof. W. Baldwin, M.A., *University of Victoria, Melbourne* *ann.*
1884 Spring-Rice, S. E., *H. M. Treasury, Whitehall*............................... *C.*
*1884 Stewart, Prof. Chas., V.P.L.S., *Royal College of Surgeons, Lincoln's Inn Fields, W.C.* .... *ann.*
†1884 Sutherland, The Duke of, K.G., *Stafford House, St. James', S.W.* ... *C.*
1894 Sykes, E. R., 13, *Doughty Street, London, W.C.*............................ *ann.*

1894 Thomas, W. F., *Bishopshalt, Hillingdon, Middlesex* .... *ann.*
1890 Thompson, Herbert, B.A., 35, *Wimpole Street, W.*......................... *ann.*
1884 Thornycroft, John I., *Eyot Villa, Chiswick Mall*............................. *ann.*
1888 Thurston, Edgar, *Government Central Museum, Egmore, Madras* ... *ann.*
1888 Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport* .... *ann.*

1888 Vallentin, Rupert, 18, *Kimberley Road, Falmouth* .... *ann.*
1891 Vaughan, Henry, 28, *Cumberland Terrace, N.W.* .... *ann.*
1884 Venning, Mrs., 3, *Wingfield Villas, Stoke, Devon* £50
1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford*.. *ann.*

1884 Walker, Alfred O., *Nantyglyn, Colwyn Bay, N. Wales* .... *ann.*
1884 Walker, P. F., 36, *Princes Gardens, S.W.* .... *ann.*
1893 Walker, W. H., 3, *Prince's Place, Plymouth* .... *ann.*
†1884 Walsingham, Lord, F.R.S., *Merton Hall, Thetford*........................... £20
1890 Waterhouse, Edwin, *Feldemore, Dorking* .... *ann.*
1888 Weiss, Prof. F. Ernest, 4, *Clifton Avenue, Fallowfield, Manchester*... *ann.*
1890 Were, Nicholas, 9, *Osborne Place, Plymouth*.................................. *ann.*
1891 Wildy, A. G., 13, *Furnival's Inn, E.C.* .... *ann.*
1884 Wilson, Scott B., *Heather Bank, Weybridge Heath* .... *C.*

1884 Woodall, John W., M.A., F.G.S., *St. Nicholas House, Scarborough*... *ann.*

1891 Young, Sydney, M.D., 13, *Aberdeen Terrace, White Ladies Road, Bristol*........ *ann.*

IV.—Associate Members.

1889 Alward, George, 11, *Hainton Street, Great Grimsby.*
1889 Caux, J. W. de, *Great Yarmouth.*
1889 Dannevig, Capt. G. M., *Arendal, Norway.*
1889 Dunn, Matthias, *Mevagissey.*
1889 Olsen, O. T , F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
1889 Ridge, B. J., 3, *Gainsboro' Place, Mutley, Plymouth.*
1890 Roach, W., *Sussex Street, Plymouth.*
1889 Shrubsole, W. H., 62, *High Street, Sheerness-on-Sea.*
1889 Sinel, Joseph, 2, *Peel Villas, Cleveland Road, Jersey.*
1890 Spencer, R. L., *L. and N.W. Depôt, Guernsey.*
1890 Wells, W., *The Aquarium, Brighton.*
1889 Wilcocks, J. C., *May Cottage, Shoreham, Sussex.*
1890 Wiseman, Fred., *Buckland House, Paglesham, Rochford, Essex.*

Director's Report.

Important changes have taken place in the staff of the Plymouth Laboratory, owing to the resignation of Mr. E. J. Bles and the transference of Mr. Cunningham to the North Sea, to continue the fishery investigations carried on there. It is with great regret that I have to report that, owing to the unsatisfactory state of his health, Mr. Holt is unable to continue the valuable work which he has been doing for the Association.

Two naturalists are at present visiting the Laboratory—Mr. J. C. Sumner, who has occupied since the beginning of January a British Association Table, and is engaged in a study of the Echinoderm fauna of Plymouth, and Mr. Richard Assheton, M.A., who is studying the development of Elasmobranchs.

An important alteration is in contemplation in the system of supplying sea-water to the tanks in the Laboratory, which it is hoped will lead to more satisfactory results than have previously been attained. In addition to this, arrangements are being made to bring in water from the open sea in sufficient quantity for delicate experiments, and a definite study of the conditions necessary for the healthy life and development of marine organisms in confinement will be attempted. In this connection I may draw attention to the interesting results contained in the paper by Mr. Darnell-Smith, published in the present number of the Journal. Mr. Darnell-Smith purposes continuing this work during the summer.

I am glad to be able to announce also that the Council have authorised the expenditure of a considerably larger sum for boat-hire during the present year than has been spent in previous years, and it will now be possible to extend the regular dredging and trawling work along the coast, and to visit the rich outlying grounds. It is fully recognised by zoologists that the work of the Association has been very greatly hampered by the want of a larger boat, and it is, in part, to make it clear to all that this is the case that the extra money is to be spent on boat-hire for this year. I would, therefore, make a special appeal to naturalists for support *during the present year*, as I am fully convinced that the results which are attained will have an important bearing on the question of our having a suitable boat of our own. A general scheme will be set on foot to map out the fauna and flora of the neighbourhood, and to arrange types for the museum ; and the Council has directed that tables be placed at the disposal of naturalists who will be willing to assist in this work. I shall be glad to hear from any workers, either zoologists or botanists, who would render help in such faunistic work. An exceptionally good opportunity is thus offered to young men who have recently finished their University course, and are anxious to gain experience in the outdoor work of Marine Natural History. At the same time increased advantages in the supply of material will be afforded to all naturalists who visit the Laboratory, and it is hoped that an exceptional effort will be made to do so by all who are interested in the prosperity of Marine Biology in this country.

Special attention is being paid to the reagents supplied to workers in the Laboratory, and all stains and more delicate chemicals are being obtained from Dr. Grübler's Laboratory, which offers the very best guarantee of their suitability for the purposes for which they are required.

The unexpected loss of Mr. Holt's services, and the fact that Mr. Cunningham has taken charge of the work in the North Sea, render it impossible for me to indicate at the present moment the definite plan of fishery work which will be adopted at Plymouth for the year. This will, however, be arranged with as little delay as possible, and no effort will be spared to carry it to a successful conclusion.

E. J. Allen.

February, 1895.

Journal of the Marine Biological Association.

A List of the Nemertines of Plymouth Sound.

By

T. H. Riches, B.A.,
Caius College, Cambridge.

The present list, the result of observations made at intervals in the course of last year, was undertaken with the view of determining for embryological purposes the resources of the Sound with regard to this group. It includes the species obtained during a great part of the year 1892.

Of the species recorded by McIntosh (**1**) as British, all but seven are here enumerated.* Of these seven, three, *Amphiporus hastatus, Tetrastemma Robertianæ,* and *Valencinia lineformis,* are northern forms, occurring in Bressay Sound, Shetland, though one specimen of the first has been taken by Hubrecht (**2**) at Naples, and two by Joubin (**4**) at Roscoff. One, *Borlasia Elizabethæ,* is a southern form, not yet recorded north of Herm. The fourth, *Meckelia asulcata,* described by McIntosh as having a wide range, has not been met with by any other writer. The fifth, *Nemertes carcinophila,* though included among the British Nemertines, has apparently not been found on the British shores—at least the only localities mentioned by McIntosh are Messina and the coast of Belgium. The last, *Amphiporus pulcher,* is said "to be generally diffused round the British coasts in water eight to thirty fathoms deep," and seems to be common on the French coast and in the Mediterranean. I am inclined to think that a species which I describe below under the name of *Amphiporus dissimulans,* and which much resembles *A. pulcher* in appearance, has occasionally been taken for the latter.

Since the publication of the monograph I only know of one addition to the Nemertine fauna of Britain, the interesting *Carinoma Armandi.* This has unfortunately not yet been found here.

The total number of species here recorded is thirty-two. Four of these are new, *Tetrastemma nigrum, T. immutabile, T. ambiguum,* and *Amphiporus dissimulans;* one, *Nemertes candida,* is new to

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* An eighth, the deep-water *Cerebratulus marginatus,* should be added to the number of the British species which I have not yet obtained.

Great Britain; two are new to the coast of Britain, *Carinella polymorpha* and *Micrura aurantiaca,* these not being recorded previously north of the island of Herm; while *Drepanophorus rubrostriatus,* if, as I believe, identical with *Amphiporus spectabilis,* has not been met with north of Guernsey.

Of the parasitic forms I have only obtained *Malacobdella.* I have, however, examined several specimens of *Galathea strigosa* for Dieck's *Cephalothrix Galatheæ,* which he describes as parasitic upon the eggs and on the gills of this crustacean, and which I believe no other writer has seen. With regard to this species, I may remark in passing that it has been erroneously referred to the genus *Carinella* by Joubin and J. V. Carus (**8**). With the same want of success I have examined large numbers of specimens of *Phallusia mammillata* and other Ascidians for Joubin's *Amphiporus vittatus* and *Tetrastemma Marionis,* and an examination of female specimens in berry of *Carcinus mænas* has not resulted in finding *Nemertes carcinophila.*

In spite of the, in many cases, brilliant colours exhibited by Nemertines, and although many of them are conspicuously marked, I have been unable to find any very definite relation in this respect to the surroundings. This want of relation is especially marked among the Tetrastemmidæ, which exhibit a very large amount of colour variation, and yet varieties the most divergent in this respect live together under apparently the same conditions. The genus *Tetrastemma* exhibits a very high degree of variation among its members, not only in colour, but also in marking and in general appearance unconnected with colour. These variations will be described in some detail below. I will only now remark that varieties have been obtained which in many respects connect such well-marked species as *T. candidum, T. vermiculatum,* and *T. melanocephalum.*

The observations of Keferstein, Claparède, and others on the existence of otocysts among the Nemertea seem not to be in favour with most modern writers. Bürger (**6**), however, in a paper published in November, 1891, stated that he had observed otocysts of oval form which were situated one on each half of the brain in some unidentified enoplous Nemertines, which he found living in sand with *Lineus lacteus* and Amphioxus. A week later du Plessis (**11**) published a paper on the subject, in which he described a pair of otocysts which he found in a thin orange-red eyeless Nemertine of 15 to 20 mm. in length, obtained under stones between tide-marks at Nice. These otocysts resembled those described by Bürger, and differed in many points from those observed by Claparède and Keferstein. On May 14th I found in sand on Drake's Island between tide-marks a few specimens of an armed Nemertine associated with *Lineus lacteus.* Each of these specimens exhibited a pair of otocysts of relatively large size, one on each ventral brain lobe just posterior to the ventral commissure. In the centre of each capsule was a single refringent otolith; no cilia could be detected. Like the two previous writers, with whose accounts I was not at that time acquainted, I failed to identify the bearers of these interesting structures. They were unfortunately lost before I had completed my examination of them. The following points, however, were made out:—Length from 1 to 2 cm. Two of the specimens were pure white, the third was pinkish posteriorly; brain conspicuously red; head rounded, with oval transparency in dorso-median line; generative organs ripe. Proboscis long, reaching to end of body, with anterior terminal pore, with median stylet and two accessory capsules, one containing several reserve stylets, the other only two; mouth in front of ganglia; eyeless. It seems to me very probable that Bürger, du Plessis, and myself have found the same species, since not only are the otocysts precisely the same in structure, but the accounts of the worms themselves, though meagre, are in agreement, and all of them are found living under the same conditions. Du Plessis attempts to correlate the presence of otocysts with the absence of eyes, but the latter condition is not infrequent among Nemertines, while the rarity of those with otocysts is sufficiently evinced by the general scepticism with which their existence has been regarded. Joubin, in his *Poliopsis*, describes structures which he at first took for otocysts, but afterwards found to be the blind ends of the ciliated canals of the side organs. The otocysts above mentioned cannot, however, be thus explained away.

The classification of the Nemertines has until lately been very defective. In 1890 Bürger, in his admirable paper on the anatomy and zoology of the Nemertea (**5**), very ably criticised Hubrecht's system, which he showed to be untenable, and proposed temporarily to return to that of Schultze. In the following year (**6**) he brought out a new scheme dealing with the primary subdivisions only. In his system these are four in number, and are based upon the situation of the nerve-stems. Last March (**7**) this system was further developed and carried into detail as regards three of the subdivisions. One of them, however, that corresponding to the *Enopla* of Schultze, was left for a future paper, which as far as I am aware has not yet appeared.

As this classification will be the one here adopted, it may be well to state at once its leading characters. According to Bürger's scheme the whole group consists of the four following orders:

I. *PROTONEMERTINI* (*Carinella*, *Carinina*, and *Hubrechtia*).—Lateral nerves outside the circular muscular layer, situated either in the epidermis or beneath the basement membrane.

II. *MESONEMERTINI* (*Cephalothrix* and *Carinoma*).—Lateral nerves have penetrated the circular muscular layer, and lie embedded in the longitudinal layer.

III. *METANEMERTINI* (Hoplonemertini of Hubrecht).—Lateral nerves have penetrated the longitudinal muscular layer, and lie in the body parenchyma.

IV. *HETERONEMERTINI* (Schizonemertini of Hubrecht, together with the genera *Eupolia* and *Valencinia*).—Lateral nerves in the same position as in *Carinella*, but between the epidermis and the circular muscular layer a layer has developed consisting of gland-cells, connective tissue, and longitudinal muscles, in which the nerve-stems lie.

Of these divisions, that of the *Protonemertini* is of course regarded as the oldest, and Bürger regards it as giving rise to the *Mesonemertini* through *Carinella*, and to the *Heteronemertini* through his new form *Hubrechtia desiderata*, for which he has established a new family, *Hubrechtiadæ*. The *Metanemertini* he considers to have arisen from the *Mesonemertini*.

The subordinate changes concern the order *Heteronemertini*. This order is divided into two families,—the *Eupoliadæ*, including the genera *Eupolia* and *Valencinia*; and the *Lineidæ*. The latter consists of two sections, the *Micruræ* and the *Amicruræ*, characterised by the presence or absence of a caudal appendage. To the *Amicruræ* belong the genera *Micrura*, *Cerebratulus*, and *Langia*. Of these the first two were united by Hubrecht under the name of the second. They are now again separated, the differentiating characters being those of general shape and mode of life.

In the above arrangement of the Lineidæ there is obviously a return to the scheme laid down by McIntosh. Hubrecht objected to the caudal appendage being regarded as a feature of generic value, and while thus abolishing the genus *Micrura* and including its species under *Cerebratulus*, he added to the latter all the shorter and broader species included by McIntosh under *Lineus*, with the result of establishing two genera, *Lineus* and *Cerebratulus*, with absolutely no point of difference except a very problematical ontogenetic difference. With our present knowledge there are, it appears to me, only two ways out of this difficulty. Either the genera *Lineus* and *Cerebratulus* must be fused into one, with the result of forming a very large genus—a method of escape suggested by Hubrecht himself (3); or there must be a reversion to the McIntoshian system, which, with some alterations in detail, is the method adopted by Bürger. Of the two alternatives there can be no doubt that the last is much the better, and in spite of the absence of any striking structural differences between the genera *Cerebratulus* and *Micrura,* and only that of the caudal appendage between these and *Lineus,* this arrangement is much more convenient and natural.

With regard to the spawning periods of the various species my observations are not at present very complete. It may, however, be stated generally, that during the whole year some one or more species are breeding, and I was considerably astonished to find a large number of species with ripe generative products from late summer to the middle of December when I left Plymouth. During this period my specimens of *A. dissimulans* laid several batches of fertilized eggs, and all the species of *Tetrastemma* and many *Schizonemertines* were ripe, as was also the parasite *Malacobdella.* The tow-net, too, contained many pilidia of different species, as well as numbers of *Cephalothrix* larvæ. The presence of the latter was surprising, as I did not meet with any ripe adults later than August.

I have nothing to add to the observations of Joubin on the vertical distribution of these forms, with which my own substantially agree.

I have not attempted to give a list of the synonyms ; a few only are given in the case of especially interesting species, or where there have been any recent changes in nomenclature.

The definitions of the different groups are those of Bürger.

Order 1.—**PROTONEMERTINI,** *Bürger.*

Brain and lateral nerves lie outside the muscular coat of the body-wall, either in the epidermis or beneath the basement membrane. Body-wall consists of epidermis and of a circular and longitudinal muscular layer. Mouth behind brain. Proboscis without a stylet.

Family CARINELLIDÆ (*McIntosh*).

Genus CARINELLA, Johnston.

1. C. POLYMORPHA, *Renier, Hubrecht.*

VALENCINIA SPLENDIDA, *de Quatr.*
TUBULANUS POLYMORPHUS, *Renier.*
CARINELLA ANNULATA (pars), *McIntosh.*

Only one specimen has been obtained. It was dredged in 25 fathoms off Stoke Point on March 22nd, and its occurrence was recorded in the Journal of this Association for that month. As I then pointed out, it has not before been noticed on the British coast. I suggested, however, that a worm described by McIntosh as a variety of *C. annulata,* and obtained by him from the island of Herm, was probably identical with this form, and I am still inclined to think that this is the case. In the record to which I have alluded, I mentioned that upon very close examination under a lens extremely faint lines could be detected, apparently similar in position to those of *C. annulata,* except that the median ventral line was absent; these lines not being white, but distinguishable by the red colour being along their course somewhat paler than elsewhere. In the absence of the median ventral line this species resembles *C. McIntoshii.* In his specimen from Herm McIntosh describes a pale lateral line on each side, and faint transverse bars on the dorsum. These lines are not mentioned by other writers, nevertheless the general ground colour and the shape and size of the head sufficiently characterise my specimen as belonging to this species.

Distribution: Naples, but not common (Bürger); fairly common on French coast (Joubin).

2. C. LINEARIS (*Montagu,* MS.), *McIntosh.*

LINEUS LINEARIS, *Montagu,* MS.
CARINELLA ALBIDA, *Bürger.*

The validity of this species has lately been called in question by Joubin, who is inclined to regard it as identical with *Valencinia longirostris.* There is no doubt great external similarity, but sections clearly reveal that the two specimens which I refer here belong to the genus *Carinella,* and not to *Valencinia.* The position of the nerve-cords between the basement membrane and the muscular coat of the body, and the absence of an outer longitudinal muscular layer, in which in *Valencinia* the nerve-stems lie, are quite conclusive as to this.

Both my specimens were dredged at the Duke Rock, the one on May 17th, the other on September 30th. Both were small, the second specimen measuring 1 cm. in length and 0·5 mm. in breadth. The first specimen was too mutilated to allow of measurement, but, judging from the size of the head, was much the same length as the other. The colour was milk-white in both cases, but in the first specimen there was a reddish tinge over the head. A transverse groove was present at the back of the head dorsally, but was difficult to trace. The head was broader than the body and somewhat spathulate, though its mobility was such that no very definite shape could be assigned to it, the snout being at one time pointed, at another rounded in outline. Passing from the point of the snout to the posterior region of the head was a median dark line, due apparently to a central opacity in this position, the rest of the head being relatively transparent. The mouth was a longitudinal slit in the position characteristic of the genus. The eyes were absent.

The short description which Bürger gives of his *Carinella albida* is so applicable to my specimens that I am inclined to regard it as identical with this species.

Distribution: South coast of England, and Lochmaddy in the Hebrides (McIntosh); Rizomi di Posidonia, Posilipo, not uncommon (Bürger).

3. C. ANNULATA, *Montagu.*

VALENCINIA ORNATA, *Quatr.*
CARINELLA ANNULATA (pars), *McIntosh.*
— — (pars), *Hubrecht.*
— — *Joubin.*

In the *Carinella annulata* of McIntosh, Bürger distinguishes two species, differing in colour, marking, size, and in the number and structure of the side organs.

Of the present species only one specimen has been obtained, and this was a fragment without head or tail of about 1 cm. in length. It was, however, readily recognisable by the presence of a median ventral white line. This specimen was dredged in nearly 40 fathoms, about six miles S.E. of the Mewstone. The apparent rarity of this species is, I believe, solely due to its living at depths at present quite inaccessible to us. While at St. Andrews I obtained a large number of specimens which were found adhering to the long lines of the haddock fishermen, and were thus brought up from considerable depths.

4. C. McINTOSHII, *Bürger.*

CARINELLA ANNULATA (pars), *McIntosh.*
— — (pars), *Hubrecht.*
— ARAGOI, *Joubin.*

Not uncommonly dredged in from 5 to 20 fathoms. Readily distinguishable from the last by its much smaller size, its white snout, the different relation of the white rings to each other, and the absence of a median ventral white line.

The chocolate variety, though rarer than the dark red, has been met with on several occasions. Many specimens obtained during the summer months had the white dots on the dorso-lateral regions of the middle and posterior parts of the body which mark the external openings of the generative organs. Whether the presence of these spots indicates sexual activity I do not know. Although many specimens were kept in captivity they did not spawn.

Order 2.—MESONEMERTINI, *Bürger.*

The lateral nerves are pushed down into the body musculature. The body-wall consists of epidermis, a circular and a longitudinal muscular layer. Mouth behind brain. Proboscis without a stylet.

Family CEPHALOTHRICIDÆ, *McIntosh.*

To this family, in addition to *Cephalothrix,* Bürger assigns *Carinoma.* He characterises it as follows:—Lateral nerves situated in the longitudinal muscular layer. Neither cephalic grooves, clefts, nor side organs present.

The negative characters here assigned, and which are repeated in the definition of the genus *Cephalothrix,* can scarcely be accepted in view of the recent positive statement by Joubin of the existence of side organs in *Cephalothrix linearis,* strengthening as it does the earlier assertion of Barrois (**9**) to the same effect. In 1877 Barrois stated, "Les organs latéraux du *Cephalothrix linearis* sont, en général, peu accusés ; c'est là, ce qui fait que plusieurs auteurs les ont laissé passer inaperçus et ont dessiné le Némerte comme en étant dépourvu ; je me suis assuré que c'était là une erreur : ces organes existent très-bien chez le Cephalothrix adulte et y présentent, avec le système nerveux, une disposition analogue à celle des Lineus."

This statement has been persistently neglected, but now that these organs have been again described, and this time with figures, their existence can scarcely be doubtful.

Genus CEPHALOTHRIX, Oersted.

5. C. LINEARIS, *Rathke, Oersted.*

This species appears to be much less common than the next, and reaches a very much greater size. Though I have never found any specimens of the gigantic length of 50—60 cm., such as Joubin describes are obtained on the French coast, I have had several varying from 10 to 15 cm. in length. A few individuals have been obtained by dredging in the deeper water outside the Breakwater, but the bulk of my specimens have been obtained in the sand between tide-marks at Rum Bay. They have not yet been found in a similar situation in any other locality. Joubin states that his specimens came from black muddy sand, and he contrasts this species with *C. bioculata* in this respect, as, according to him, the latter lives in pure yellow sand. This difference of habitat in the case of the two species does not appear to hold good for Plymouth forms. Here both species are found in clean coarse sand, and I have occasionally found *C. bioculata* in black mud.

6. C. BIOCULATA, *Oersted.*

This common species may be obtained almost everywhere between tide-marks. As I have already said, a few specimens have been occasionally found in black mud, but the majority in clean, coarse sand. Large numbers live among corallines, and may be captured by collecting the latter. Unless Bürger's *C. hymenæus* is a variety of this species, it does not occur at Naples, but the difference between them is very slight, consisting as regards *C. hymenæus* in a reduction of the red pigment on the head to the two red specks, and the presence of grains of blue pigment in the latter. A difference of habitat is also mentioned, *C. hymenæus* never being found in sand, but associated with *Tetrastemma coronatum.* At Plymouth *Tetrastemma coronatum* is abundant among the corallines in tide-pools, where it is associated with the present species.

The breeding period lasts from early spring until the beginning of autumn. Ripe specimens were first found in April, and none were found later than August. As I have already mentioned, pelagic larvæ were obtained from the tow-net as late as December. The largest of these was 3 mm. long, and was provided with an additional pair of marginal lappets, situated between the pair figured by McIntosh and Barrois and the anterior extremity. The eyes were situated at the margin of the head, and relatively far back. Some days after the capture of this larva it gave up pelagic life, and sank to the bottom of the vessel. About this time the eyes began to atrophy, and very shortly the adult appearance was reached. I have succeeded in getting this species to breed in captivity, and hope soon to publish an account of its development.

Order 3.—**METANEMERTINI**, *Bürger.*

The lateral nerves have completely broken through the muscular coat of the body-wall, and have come to lie within it in the parenchyma. The body-wall consists of epidermis, a circular muscular layer, and a longitudinal muscular layer. The mouth is situated in front of the brain. The proboscis, with few exceptions, is provided with a stylet.

Family AMPHIPORIDÆ, *Hubrecht.*

Genus AMPHIPORUS, Ehrenberg.

7. A. LACTIFLOREUS, *McIntosh.*

Nearly as common as *L. obscurus.* Lives between tide-marks under stones. The arrangement of the eyes in two groups on each side, the posterior group generally forming a triangle, with one eye-speck (that most remote from the snout) much larger than the rest, is very characteristic.

The colour is very variable; many shades of white and whitish pink are represented, but the commonest colour is perhaps light brown. I have never met with a green variety, though this seems common on the French coast, and has been found at Guernsey.

Ripe specimens and eggs were found in the early spring.

8. A. DISSIMULANS, n. sp.

I have established this species for a very abundant Amphiporus which I at first took to be *Amphiporus pulcher.* It agreed with this species in the general shape of the body, with its oar-like tail; in the broadly spathulate pointed head, so different in appearance from that of *A. lactifloreus,* and, in contrast to the latter, sharply separated from the body; in the arrangement of the eyes, which are never divided into groups; and in habitat occurring only in from 15 to 20 fathoms.

The average length is 5 cm.; the colour is variable, but most frequently is a very pale pink, the pink being rather pronounced anteriorly, but posteriorly passing into a bluish tint. The tip of the snout has a central papilla, from which an opaque line passes back a short distance. The eyes are very numerous; in one specimen I counted forty on one side. The brain can be seen as a red object shining through the skin, but it is not so conspicuous as in *A. lactifloreus.*

The arrangement of the cephalic grooves is somewhat peculiar, it is the same as that described by Joubin in *A. pulcher.*

In the characters just given, the specimens included here do not seriously differ from *A. pulcher,* but they differ essentially in the structure of their proboscis, which resembles that of *A. lactifloreus,* while that of *A. pulcher,* according to the description given by McIntosh, is widely different, and in the situation of their side organs, which is in front of the brain as in *A. lactifloreus,* and not behind it.

These differences in proboscis structure and in position of the side organs rendering it impossible to assign these specimens to the species *A. pulcher,* it yet remains whether they ought not to be considered varieties of *A. lactifloreus.* But against this view are the characters above given of the shape of the head and of the tail, the number and arrangement of the eyes, the position of the cephalic grooves, and the difference of habitat, *A. lactifloreus* being a shallow water form, and these specimens being never obtained in less than 15 fathoms.

It seems very probable that this species has been occasionally described as *A. pulcher.* Joubin, for instance, in describing the specimens at Roscoff and Banyuls says nothing of the peculiar structure of the stylet region of the proboscis, so characteristic of the latter species, nor does he mention the situation of the side organs. On the other hand, he says that he has not seen the secondary cephalic grooves described by McIntosh ; and his figure of the arrangement of the primary grooves is, as has been said, perfectly applicable to this species. While, moreover, McIntosh finds only twenty-three eyes on each side of the head, Joubin describes as many as thirty-five or forty-five.

Ripe specimens occur in the spring, but are more common in October, at a time when *A. lactifloreus* is not breeding.

The only locality from which this species has hitherto been obtained is the Millbay Channel, where it occurs in considerable numbers.

9. A. BIOCULATUS, *McIntosh.*

Only one specimen of this northern species has been obtained. It was dredged in Millbay Channel on November 18th, with many examples of the last species. Its length was about 1 cm. In colour it was somewhat different from that of specimens previously described, being a milky white, while the Shetland specimens were dull orange, and the two obtained at Roscoff were green. The description and figure of the head given by Joubin exactly apply to the present specimen.

This species has not yet been found in the Mediterranean, and this is the only record from the coast of England.

Genus DREPANOPHORUS, Hubrecht.

10. D. RUBROSTRIATUS, *Hubrecht.*

AMPHIPORUS SPECTABILIS, *McIntosh.*

This species has been the centre of much controversy, and there is still some confusion regarding it. The controversy concerns the identity or non-identity of the Naples *Drepanophorus rubrostriatus* with the Atlantic *Amphiporus spectabilis* of McIntosh. Hubrecht is of opinion that they are not identical, and he accuses McIntosh of having referred the anatomical points which he obtained from Mediterranean forms to Atlantic specimens, thus, according to Hubrecht, "confounding specimens, species, and even genera." As far as I understand Hubrecht's position, he maintains that there are two species belonging to distinct genera, the one being an *Amphiporus*, the other a *Drepanophorus*, and that these two present great external similarity, and have hence been confounded; that the *Drepanophorus* is restricted to the Mediterranean; and that the Atlantic form described by McIntosh as *Amphiporus spectabilis* is distinct from it, being identical with the *Amphiporus splendidus* of Keferstein and Barrois, and not with the *Cerebratulus spectabilis* of De Quatrefages, which he regards as synonymous with his own species.

Joubin, on the other hand, who has had the advantage of working at both Atlantic and Mediterranean Nemertines, is of opinion that the two are identical, though he does not appear to have had anatomical evidence for this.

Apart from the very remarkable curved stylet in the proboscis, the genus *Drepanophorus* is characterised by the presence of transverse cæca belonging to the proboscis sheath, these cæca being arranged metamerically. And this character alone has been used by Hubrecht in referring some of his "Challenger" specimens to this genus. Now the specimens that I have obtained at Plymouth, which are in complete agreement with the description given by McIntosh of *Amphiporus spectabilis* in his monograph (his views as to the proboscis—which, however, he afterwards admitted to be erroneous—alone excepted), exhibit very clearly in sections these metameric cæca, so that no doubt can remain that they belong to the genus *Drepanophorus*. This being so, is not the identity of the *Amphiporus spectabilis* of McIntosh with Hubrecht's *Drepanophorus rubrostriatus* established?

Five specimens have been found. The first came from weeds dredged in Cawsand Bay on November 11th. It was 2 cm. in length, and exhibited the bright red stripes shown in Joubin's figure. All the rest were dredged at Stork Point during the same month, and were found inside the honeycombed stones with which the bottom is there strewn. These specimens were considerably larger than the first, the largest being something over 6 cm. in length and the smallest between 3 and 4 cm. In all these the colour was much paler than in the Cawsand Bay specimen, the red lines being represented by buff-coloured lines, and the intermediate lines being grey instead of pale pink. In these larger individuals the generative organs were ripe.

This species has not previously been recorded so far north. It occurs on the Atlantic shores of France, but is much more common in the Mediterranean. A single specimen was found at Guernsey by McIntosh.

Family TETRASTEMMIDÆ, *Hubrecht.*

Genus TETRASTEMMA, Ehrenberg.

As has been already remarked, this genus is characterised by the very high degree of variation which its members exhibit. It is for this reason in many cases extremely difficult to identify a given species, or to come to anything like a satisfactory conclusion as to the amount and kind of difference which justifies specific separation. Such conclusions as are expressed by the recognition of the following species are provisional. They are, however, based on a consideration of the kind and degree of variation exhibited in each case.

11. T. FLAVIDUM, *Ehrenberg.*

This species is very different in appearance from the other members of the genus, and, unlike them, exhibits very little variation. It is very common, and may be found between tide-marks, but it is obtained in larger numbers by dredging in from 5 to 20 fathoms. The Duke Rock and Millbay Channel are favorable localities.

Ripe specimens occur in autumn.

12. T. DORSALE, *Abildgaard.*

This very common species seems to inhabit every level from Joubin's second zone to his fifth. It was especially common in spring and early summer among the Zostera in Cawsand Bay. Later in the year, however, it became less common in this locality, and late in the autumn it was quite the exception to find a single individual there, when a small Terebellid seemed to have taken its place.

Several varieties have been met with, agreeing with those described by other writers, but all were marbled. This species agrees with the two following, and differs from all other Tetrastemmas in the rounded shape of the body, and in the absence of a well-defined head region, so characteristic of the remaining species.

The breeding season is the autumn.

13. T. NIGRUM, n. sp.

I describe under this name a species which I at first considered as a variety of the last. Like *Tetrastemma dorsale* it has a rounded body, and there is no well-marked head ; but though highly variable in marking, it yet maintains certain characteristics to which no varieties of *T. dorsale* that I have met with in any way approach. The general ground colour, which is a pale yellow, may be entirely or partially hidden by a strong development of a very dark brown, almost black pigment, which is in the form of a close network. This dark pigment either covers the dorsal surface of the animal entirely, rendering it quite black to the naked eye, or the median dorsal line is left uncovered, which thus appears as a median yellow stripe. This stripe passes from the anterior to the posterior extremity, and is generally interrupted, but quite irregularly, by bridges of the dark pigment stretching across it. The breadth of the stripe is very variable, both in different animals and in different regions of the same animal, and its edges are much frayed. The cephalic grooves are more apparent than in the case of *T. dorsale*, owing to the absence of the dark pigment at their edges; but the eyes, which are reddish, have the same position, and are deeply placed. The stylet region of the proboscis resembles that of *T. dorsale*, but there is considerable variability in the shape of the stylet handle.

This species is most commonly found on *Codium*, which it in some degree resembles in colour, enough at least to make it difficult to find. I have, however, obtained it from weeds of various kinds, in the Laminarian zone. The average length is 1 cm.

14. T. IMMUTABILE, n. sp.

The specimens brought together under this name are perhaps identical with one described by Joubin as a variety of *T. dorsale*. From this species, however, they differ at least as much as many species (which are regarded by every one as distinct) do from each other. I am, moreover, inclined to regard them as constituting a distinct species, because in spite of the variability of *T. dorsale* I have met with no variations which in any way approach them in colour and marking, and they, on the other hand, are singularly invariable.

The length ranges from 5 mm. to 1 cm. The body is rounded, and ends abruptly both anteriorly and posteriorly as in *T. dorsale;* the head, however, is more apparent than in the latter, owing to the slight amount of pigment there distributed. The ground colour is yellow, with a sprinkling of orange-red granules, which are strongly concentrated in the median dorsal line, forming a stripe of chocolate colour, beginning just in front of the anterior pair of eyes, and passing backward to the posterior end of the body.

The eyes are black, and similarly situated to those of *T. dorsale.* Many specimens have been found in the coralline pools at Wembury Bay, and they are also met with among the weeds in the second and third zones, and dredged at the Duke Rock. In all these places they are associated with other species of *Tetrastemma,* including *T. dorsale.*

15. T. CANDIDUM, *O. F. Müller, Oersted.*

Agrees with the remaining species of this genus, and differs from the last three in its more or less flattened body, in marked contrast to the rounded body of *T. dorsale* and its allies, and in its sharply separated spathulate head. The species now to be considered are also characterised by their excessive variability. Only one specimen resembling the type form of McIntosh has been obtained; this was found by Mr. Garstang in sand between tide-marks at Rum Bay on the 21st of July.

The reddish and yellow varieties are not uncommon. They are found, though in small numbers, in Cawsand Bay among the weeds. Larger specimens are dredged in 5—20 fathoms, and they appear to be more numerous at the greater depth. Thus specimens have been dredged at the Duke Rock, and in Millbay Channel, but the majority have come from Stoke Point, where they seem to live associated with *Lepralia,* which they closely resemble in colour. The positive points characterising this species seem to consist in the shape of the head, which is more rounded than in the other members of the genus, in the definiteness of the cephalic grooves, which give the head a very characteristic appearance, and in the clearness and distinctness of the eyes, which are round and black. But in these as in other points there is great variation, and some varieties seem to form a series bridging the gulf separating this from the succeeding species. An interesting instance of this variation was exhibited by a Tetrastemma obtained in October, and which, while agreeing with the reddish variety of the present species in all other points, differed with regard to the anterior pair of eyes, which, instead of being compact and round, were broken up into two little masses of minute specks, invisible except under the microscope. Immediately above these disintegrated eyes on each side was a slight aggregation of orange pigment granules which passed back towards the posterior pair, but ended just in front of the anterior grooves. In this and the following species there is a tendency towards the formation of a median dorsal white line, passing from the snout to the posterior extremity. In this specimen the white line was conspicuous, though somewhat interrupted in its course posteriorly, and on the snout it was continuous with an oval patch of the same white pigment.

In the slight development of pigment between the anterior and posterior eyes, the specimen just described exhibited a character which reappeared in another obtained from weeds collected at Redding Point. In this specimen, which was of a green colour and much resembled the type form, the anterior eyes were normal, and close behind them on each side was a little patch of orange pigment which, as in the last case, passed backwards towards the posterior eyes, becoming imperceptible behind the anterior grooves. A thin median dorsal white line passed backward from the snout, but came to an end just behind the posterior eyes. The shape of the head of this specimen, and the distinctness of the eyes, as well as the structure of the stylet region of the proboscis, clearly indicated that it belonged to this species. In this development of pigment between the anterior and posterior eyes, however, there is the suggestion of a transition to *T. vermiculatum*. This suggestion gathers force with the finding of varieties in which the characteristics of *T. vermiculatum* become more pronounced, and those of the present species less marked, until it becomes difficult to determine whether a given specimen shall be considered a variety of this or that species. One such specimen was obtained on the 21st November; it was 1 cm. long, and in colour resembled the yellow variety of this species; the anterior eyes were round and distinct; the posterior, though equally distinct, were much smaller and closer together; the anterior and posterior eyes of each side were connected by a band of bright orange pigment; the cephalic grooves were not so distinct as they usually are in this species, and the head was not so rounded. In this particular specimen the proboscis stylet resembled neither that of this nor any other species in particular; but in another, which exhibited all the above-mentioned characters, the stylet was like that of *T. vermiculatum*, the handle being much swollen at its base.

A still nearer approximation to *T. vermiculatum* was reached by an individual dredged from Millbay Channel on the 25th of November, which should perhaps be regarded as a variety of that species. This specimen, a ripe male 15 mm. long, was of a brighter yellow than the last, the colour being intensified by the presence of scattered granules of orange pigment; the head was somewhat narrow and elongated, the eyes very distinct, the posterior being very slightly smaller than the anterior, and the four forming a rectangle. The cephalic grooves were very distinct; the anterior and posterior eyes on each side were united by a band of dark brown pigment; there was a median dorsal white line on the head passing from the snout to a point just behind the posterior grooves; the proboscis stylet resembled that of *T. vermiculatum.*

According to McIntosh this species breeds in April and May as well as in the autumn. I have only found ripe specimens in autumn.

16. T. VERMICULATUM, *De Quatr., McIntosh.*

This is a fairly common species, living in weeds between tide-marks, and also in water of 5 to 20 fathoms, being frequently dredged with stones at the Duke Rock and Millbay Channel. Joubin finds that the young forms are without the pigment uniting the anterior and posterior eyes, and observes that the dorsal white line is a preferable character in distinguishing this species. On this point I cannot agree with him, as, on the one hand, I have obtained many specimens which are without the median dorsal white line; and on the other, such a line, as I have already said, appears in an erratic manner on individuals of all these species, sometimes extending from snout to tail, sometimes limited to the head, and sometimes being a mere row of white dots. With his other remark, that the oval head "est assez caractéristique," I quite agree. As in the case of the other members of this genus, the breeding period is late autumn and early winter, but, as in the last species, McIntosh found ripe specimens in spring and early summer.

17. T. MELANOCEPHALUM, *Johnst.*

T. MELANOCEPHALUM, *Hubrecht.*
T. CORONATUM, *Hubrecht.*

I agree with Joubin in regarding Hubrecht's two species, *T. melanocephalum* and *T. coronatum,* as really forming one, and I shall be surprised if his *T. diadema* does not turn out to be a variety of this species also. I have not found any specimens that perfectly agree with Hubrecht's description of the last-mentioned species, but the description given by Joubin of *T. diadema* is quite applicable to what I regard as a variety of *T. melanocephalum.* That the specimens to which I refer really belong to this species there can be little doubt, the variations by which they are connected to the type form being so numerous.

This species lives under the same conditions as the other members of the genus, and is found associated with them among weeds between tide-marks and on stones dredged in 20 fathoms.

The greater number of specimens are various shades of yellow, but a bright green variety is found in the coralline pools of Bovisand Bay. It is this variety which I think Joubin describes as *T. diadema.*

The green specimens are the longest of this species I have yet met with, commonly reaching 3 cm. in length. The pigment patch is dark brown and quadrangular in shape, with a slight tendency to concavity in front and convexity behind. There are three pronounced patches of white, two in front of the dark patch, one on each side of the head and somewhat triangular in outline, and one behind it stretching across the breadth of the posterior part of the head. I have not determined whether the white patches are pigment patches, or whether they are due to the aggregation of fatty particles, as Hubrecht suggests. The eyes are approximately of the same size, and are very distinct, the anterior pair being situated just in front of the dark patch, within which, however, they are in some specimens included.

Many specimens of the yellow variety are met with agreeing generally with the above, the majority not reaching more than 15 mm. in length (though a single specimen was found as long as 4 cm.), and exhibiting great inconstancy in the amount and distribution of the white patches, which are sometimes absent altogether, as well as in the size and intensity of the dark patch.

A common variety is that in which the pigment patch is represented by a sprinkling of brown granules over a roughly quadrilateral area situated between the two pairs of eyes. Before this pigment are two small white patches, and behind is a transverse white patch, behind which again the posterior eyes are placed. In this variety the white granules which exist, distributed irregularly over the body of most specimens, become regularly arranged along the median line, forming a series of disconnected transverse bars passing from the posterior white patch on the head to the fan, composed of radiating white lines, which is found at the tail of nearly all the yellow varieties. In one specimen I have met with a still further stage of this tendency for the white particles to aggregate along the median line. In this, which had the broad dark patch of the type form, in front of and behind which some white granules were scattered, there was a very definite and conspicuous thin white median line passing from just behind the posterior eyes to the tail.

In many, if not most specimens with a broad, well-defined, dark pigment patch on the head, those portions of the pigment which are situated in the line uniting the anterior and posterior eyes are conspicuously darker than the median portion. This tendency is expressed more strongly in some specimens than in others, until a condition is reached in which the median portion has almost entirely disappeared, leaving only a thin bridge which joins the posterior ends of two masses of pigment which extend from the anterior to the posterior eyes. Behind the pigment bridge there is a band of white separating it from the posterior eyes, but there is no white on the anterior portion of the head. A median aggregation of granules is present on the body, forming a white dotted line passing from the white head patch to the tail fan.

A specimen which was dredged in the Hamoaze near the "Royal Adelaide" on December 14th represents the final term of the series, and follows the last very closely. In this individual the pigment bridge has completely broken down, so that in this case the head is characterised by two dark patches passing from the anterior to the posterior eyes, one on each side. Between the posterior eyes there is a patch of white, but this is much smaller than in the last specimen. The posterior eyes are slightly smaller than the anterior (which was the case in the last variety), and are slightly closer together. This individual undoubtedly belongs to this species, both on account of the fact that it belongs to an entire series reaching up to the type form, and also because in the presence of the white patch between posterior eyes, in the shape of the head and the condition of the stylet region of the proboscis, it exhibits most characteristic melanocephalous features. Nevertheless this arrangement of pigment is certainly suggestive of a transition towards *T. vermiculatum*, and especially recalls varieties described as intermediate between *T. candidum* and *T. vermiculatum*.

Only one case has come under my notice in which any relation could be detected between the colour of the animal and that of its surroundings. It was that of a specimen found among red weeds. The colour of this individual was remarkable, differing entirely from any other met with. The ground colour was a greenish yellow, but this was covered superficially by minute red-brown pigment granules, the result being the production of a colour remarkably similar to that of the weeds in which it was found. The red-brown granules were concentrated on the head to form the usual quadrate patch, the edges of which were not sharply defined, and the patch itself was reddish, not black. This animal, which was 1 cm. long, was a female containing ova.

18. T. AMBIGUUM, n. sp.

Under this name I include a few specimens found in November which have many points of agreement with *T. Robertianæ*, as a variety of which species I was at first inclined to regard them. I am induced to separate them, however, because of the absence of the peculiar marking which is so characteristic of that species.

The length is about 1 cm. The head, which is very distinct from the body, is very broad at the level of the entrance to the side organs, and in shape resembles that of *T. melanocephalum.* The anterior eyes are at least twice as large as the posterior. All four are of a brown colour, of irregular shape and not well defined. The ground colour is a pale yellow. On the dorsal surface there is a considerable development of reddish-brown pigment, which covers the whole of this surface of the body from just behind the posterior grooves to the tail.

The proboscis stylet handle is of the shape described by McIntosh as characteristic of *T. Robertianæ.*

I also refer here a specimen which I found the same month, which exhibited some differences from those above described. The length was 15 mm., the colour a uniform pale yellow. The general shape and the relation of head and body was the same as in the type form. The eyes were black and fairly distinct, the anterior being nearly twice the size of the posterior. The stylet handle resembled that of *T. vermiculatum* rather than that of *T. Robertianæ.*

All these specimens had ripe generative organs.

Genus PROSORHOCHMUS, Keferstein.

McIntosh characterises this genus as follows :—"Eyes four, not forming a rectangle ; snout dimpled, and furnished with a transverse superior lobe. Ovo-viviparous." Of these three characters the first is scarcely available, as there is a general tendency towards this condition in the genus *Tetrastemma,* a tendency so great that in almost every species there are many individuals with the posterior eyes closer together than the anterior. McIntosh himself is not inclined to attach much value to the third character, as he says "it is a condition which further investigation will probably extend to many genera." The only character which is left is the second, and it appears to me questionable whether, on account of such a feature, a single species in all other respects *Tetrastemma*-like should be raised to the rank of a separate genus.

19. PROSORHOCHMUS CLAPAREDII, *Keferstein.*

Several specimens have been dredged, some from the Millbay Channel, others from the Duke Rock. None of these specimens agreed with the figure given by McIntosh either in colour or in general appearance.

The length varied from 8 mm. to 3 cm. The ground colour was a yellowish brown. This on the dorsal surface was covered by a thick uniform sprinkling of reddish-brown grains of pigment. The cephalic grooves were very pronounced. The region included between the anterior and posterior grooves was rendered conspicuous dorsally by the strong development of the reddish-brown pigment, which was here in the form of thick lines radiating forwards in all directions from a median and posterior point. The head, which was broad and conspicuous, in front of the anterior grooves was covered superficially on each side by large flakes of white pigment, which reappeared at the posterior end of the body, covering the tail. The anterior eyes were red, large, and irregularly triangular; the posterior were much smaller and rounder, and were generally closer together than the anterior, though there was sometimes little difference in this respect. The right and left lobes of the snout were very conspicuous, but the transverse dorsal lobe was more difficult to make out.

The stylet region of the proboscis, which is very characteristic, entirely agreed with the figure given by McIntosh.

The shape of the body renders this species at once recognisable. It is constricted behind the posterior grooves, gradually increases in girth up to the middle of its length, and from thence tapers to the tail.

Ripe specimens have been met with in the spring, but I have never seen a female with developing eggs.

Hubrecht did not find this species at Naples, but it was found at Trieste by Dewoletzky. It is rare at Roscoff (Joubin).

Family NEMERTIDÆ, *Hubrecht.*

Genus NEMERTES, Cuvier.

20. N. GRACILIS, *Johnston.*

Not uncommon. Almost restricted to the Breakwater, where it is found at low tide among the roots of Laminaria and in the cavities of stones. It has a wide distribution, ranging from the north of England to Madeira.

21. N. Neesii, *Oersted, McIntosh.*

Like the last, this species abounds on the Breakwater, and is scarcely found elsewhere.

The generative organs are ripe from March to October. Large numbers of eggs have been laid in my dishes, but they have always died without segmenting, though numbers of ripe males were present. Artificial fertilization has been equally a failure.

Like the last, this species is widely distributed, ranging from Iceland to the Mediterranean. It is rare at Naples according to Hubrecht.

Family MALACOBDELLIDÆ, *v. Kennel.*

Genus MALACOBDELLA, Blainv.

22. M. grossa, *Blainv.*

Several specimens of this interesting parasite have been obtained. In all cases they have been found in the branchial cavity of *Cyprina islandica.* In only one case have I examined one of these molluscs without finding a specimen, and in no case has more than one been found in a single Cyprina.

This species lives well in captivity in spite of its parasitic habits. One specimen has lived in a vessel of water submerged in a tank for more than three months, and is still apparently healthy. It moves slowly about the sides of the vessel, to which it adheres by its sucker.

In the autumn many ripe females were found, which subsequently laid unfertilized eggs, but no ripe males have been seen.

Order 4.—HETERONEMERTINI, *Bürger.*

The lateral nerves situated, as in the Protonemertini, outside the circular muscular layer. Their apparent position, however, is different, owing to the appearance of a new muscular layer (longitudinal) which has inserted itself between the basement membrane and the circular layer. The lateral nerves are situated between this layer and the circular layer.

The body-wall consists of epidermis, cutis, outer longitudinal muscular layer (new), a circular muscular layer, and an inner longitudinal muscular layer.

Mouth situated behind brain.

Proboscis without a stylet.

Family LINEIDÆ, *McIntosh.*

A. *AMICRURÆ, Bürger.*

Caudal process absent.

Genus LINEUS, Sowerby.

23. L. LONGISSIMUS (*Gunn, Sowerby*).

L. MARINUS, *McIntosh.*

Not very abundant. Occasionally dredged at the Yealm among Phallusia and other Ascidians, and in the deeper water outside the Breakwater. Sometimes found shore-hunting during very low tides among the roots of Laminaria. No specimens have been met with of the size given by McIntosh, the largest not being more than six feet long, while the majority are very much less. Apparently a northern form, as it occurs on the coasts of Norway and Belgium and the Atlantic coasts of France, but not in the Mediterranean.

24. L. OBSCURUS, *Desor.*

L. GESSERENSIS, *McIntosh.*
L. SANGUINEUS, *McIntosh.*
L. GESSERENSIS, *Joubin.*

By far the commonest Nemertine in the Sound. It is to be found everywhere between tide-marks. Joubin describes five colour varieties: (*a*) deep blue and black; (*b*) deep olive-green; (*c*) pure green; (*d*) green and red; and (*e*) red. All these varieties, with the exception perhaps of the third, I have met with in the Sound, but I have not noticed that any particular habitat is characteristic of any individual variety. In common with Hubrecht and Joubin, I regard the *L. gesserensis* and *sanguineus* of McIntosh as varieties of the same species.

Neither Hubrecht nor Bürger has found this species in the Mediterranean, but Joubin appears to have obtained it at Porte Vendres, and Dewoletzky at Trieste. It is, however, like *L. longissimus,* a northern form, though it has a greater southern extension than the latter.

According to McIntosh the breeding season lasts from January to May. Mr. Garstang tells me that during the present year he has found eggs and ripe specimens as early as January, and they are still (March) to be obtained.

25. L. LACTEUS, *Montagu.*

This species seems commoner in the Mediterranean than on the Atlantic shores; at least Joubin states that it is commoner at Banyuls than at Roscoff, and Bürger describes it as "tolerably common" at Naples, though Hubrecht does not seem to have found it there. I have not obtained many specimens. The north side of Drake's Island, between tide-marks, seems the most favorable locality, though isolated specimens have also been obtained in Cawsand Bay. All the individuals were small, measuring only from 5 to 10 cm. in length, whereas those described by McIntosh were one or two feet. I have not met with either ripe specimens or eggs. At Banyuls they are said to breed towards the end of May.

26. L. BILINEATUS, *Renier.*

CEREBRATULUS BILINEATUS, *Hubrecht.*
LINEUS BILINEATUS, *McIntosh.*

Fairly common in from 5 to 20 fathoms. It is especially abundant at the Duke Rock among the shells and stones, though numbers of individuals have been obtained from the west channel and elsewhere. One small specimen was obtained among corallines in tide-pools on the east side of Drake's Island. It is the dark-coloured specimen mentioned below. The greater number of the specimens which I have seen are small, being only from 3 to 5 cm. long. Only one was a fair size. This was dredged at the Duke Rock on May 14th. Its length could not be determined, as its tail was missing, but its breadth was 0·5 cm., so that its length when complete must have been at least 12 to 15 cm.

This species is very variable in colour. The majority of individuals were of a creamy white, inclining to reddishness. In some the brown-red pigment granules were localised in patches here and there. As the larger specimens almost invariably showed more colour than the smaller, I was inclined at first to think that these differences indicated merely stages in development. The finding, however, of a very small specimen between 2 and 3 cm. long, which was of a dark uniform chocolate-brown, seems to point rather to colour variation as the explanation, and this is strengthened by the fact that I have found specimens 4 cm. long perfectly white. The colour of the single large specimen was a beautiful dark purple.

In all the specimens I have seen the dorso-median line is double, being divided by a thin line of the same colour as that diffused over the body. Those described by Bürger from Naples are without the median dividing line, though Hubrecht has found there specimens quite typical in this respect. According to Chapuis this is a viviparous species. Dalyell, however, states that his specimens laid vast quantities of eggs in June. Unfortunately I have been unable to make any observations on this point.

B. *MICRURÆ, Bürger.*

A caudal appendage present.

Genus MICRURA, Ehrenberg, Bürger.

Includes small forms with tapering head not marked off from body. Progression by crawling, not swimming. Usually knotted in heaps or strongly contracted. Provided with a caudal appendage.

27. M. PURPUREA (*Dalyell*), *J. Müller.*

CEREBRATULUS PURPUREUS, *Hubrecht.*

A common species, dredged in 5 to 20 fathoms. The Duke Rock appears a specially favorable locality. All specimens so far met with are rather small, the largest not exceeding 5 cm. I have never found a specimen with eyes, but Joubin says that a large specimen which he obtained had a dozen extremely small eyes, which were situated on the yellow band across the snout. The ground colour is very variable, all shades of red and brown being represented as well as purple. A single light green specimen was dredged outside the Breakwater on November 7th. I have not as yet met with any ripe specimens, but Joubin records the capture of one containing eggs in June, and McIntosh in April. The voracity of this species is mentioned by McIntosh ; I met with a striking instance of it in May last. A specimen of about 3 or 4 cm. was placed in a dish with a *Nemertes Neesii* of quite 20 cm. length. Some little time after I was astonished to find the Micrura busily engaged in swallowing the Nemertes. The posterior one fifth of the latter had already disappeared into the mouth of the former when I noticed them, and still the assailant was struggling to gulp down more of its prey. In the meantime the victim glided round the dish, apparently not suffering the smallest inconvenience from the attack upon its posterior extremity. Ultimately both attacker and attacked became quiescent, the former having become more than twice its previous girth. The portion of the Nemertes in the gut of the Micrura still remained in continuity with the rest of the body, though apparently undergoing digestion.

28. M. AURANTIACA, *Grube.*

CEREBRATULUS AURANTIACUS, *Hubrecht.*

One individual only has been obtained. This was found between tide-marks at Wembury Bay on June 10th. The length was only from 3 to 4 cm., the colour bright vermilion dorsally, ventrally pale pink. Dorsally the vermilion was interrupted on each side of the middle line over a region corresponding to the hinder quarter of the cephalic slits, in such a way as to cause the appearance of a neck, the pale unpigmented edges being almost invisible in comparison with the median strongly pigmented portion. Two white patches were present, one on each side of the snout, of considerable vertical depth, as when the worm was examined laterally the white patches were seen to pass from the dorsal to the ventral lips of the cephalic slits. In the figure given by McIntosh of this species there is a single crescentic white patch, and the region in front of the crescent is pigmented like the body. In my specimen, however, not only is the patch double, but there is no pigmented region in front of it, the snout being anteriorly devoid of pigment. Eyes absent. Cephalic slits elongate and deep.

No caudal appendage was observed in this individual. This was, curiously enough, the case in the specimen described by McIntosh, for though the caudal appendage was figured by the artist, the writer states that he did not himself observe it.

Although many colour varieties of this species have been recorded, none, I believe, have been found with the anterior white patches distributed in the way above described.

This species is new to the British coast, not having been recorded further north than the island of Herm.

29. M. FASCIOLATA, *Ehrenberg.*

CEREBRATULUS FASCIOLATUS, *Hubrecht.*

This very pretty species is common in the Sound, great numbers being dredged, especially at the Duke Rock. Many varieties of different shades of red have been collected, but no green varieties, which seem to be the most abundant at Naples.

One specimen from the Duke Rock was interesting as an example of the regenerative power of this species. The whole animal was twice as long as its own cephalic slits; one transverse white band was present in the usual position of the first band, and accurately marked the middle of the animal. The head was of the size of that of a specimen of 3 or 4 cm. Just before the posterior termination of the body there was a sudden reduction in girth, followed by the usual caudal appendage.

Ripe individuals are found from October to the end of the year.

30. M. CANDIDA, *Bürger*.

NEMERTES LACTEA.
CEREBRATULUS LACTEUS, *Hubrecht*.

I refer to this species a Nemertine which was dredged at Stoke Point on the 10th of November. It was 1·5 cm. long, of an opaque white colour, and possessed a caudal appendage. Eyes seemed to be absent. Unfortunately while under observation the animal died, its body rupturing in an extraordinary manner, and from no ascertainable cause, and emitting clouds of spermatozoa.

This species has not previously been recorded in Great Britain; it is common at Naples, and occasionally found at Banyuls and Roscoff, but the absolutely white variety seems to be rare on the French coast.

Genus CEREBRATULUS, Renier, Bürger.

Relatively broad, powerful forms, which roll themselves spirally and do not tie themselves in knots. They are excellent swimmers, cutting through the water in an eel-like manner. In transverse section the body forms a long ellipse. The lateral edges of the body stand out like longitudinal folds. Head lancet-shaped. All have a caudal appendage.

31. C. FUSCUS, *McIntosh, Hubrecht*.

MICRURA FUSCA, *McIntosh*.

A few specimens only have been obtained. The first was dredged in 4 or 5 fathoms in Jennycliff Bay on November 30th, a few others were dredged between the Mallard and Cobbler Rocks. Of these specimens the smallest was 2 cm. in length, and the largest 5 cm., the latter being 3 mm. broad at the tail, and the caudal appendage reaching the length of 2·5 mm.

There is much variability in the disposition of the brown flakes of pigment on the yellow ground colour. In some specimens the brown pigment was limited to the head, in others it was present over the whole dorsal surface of the body, but in all cases it was very sparsely if at all distributed on the ventral surface.

The disposition of the eyes is very irregular. In one specimen I counted eight eyes. Two of these were situated in corresponding positions on each side of the snout, and were about four times as large as the rest. Of the remainder two were placed on the left side and four on the right, but there was no kind of regularity in their arrangement.

Joubin's figure (Pl. XXX, fig. 3) shows well the peculiar posterior end so characteristic of this species. The nervous system is conspicuously red.

32. C. PANTHERINUS, *Hubrecht.*

C. MARGINATUS (pars), *Joubin.*

I assign to this species a Cerebratulus dredged off Stoke Point on September 4th.

In colour it agreed with the last species, from which it differed in the shape of the head, the absence of eyes, and in the posterior termination of the body. The anterior end was much swollen, and waves of contraction continually passed along the whole length of the animal. When it reached me it was extremely sluggish, exhibiting no other sign of life than these contractions. The snout was very pointed, and the cephalic slits were deep with closely opposed lips. Posteriorly the lips were opened, exhibiting deep pits leading to the side organs. At this point the slits were red. The animal, which was 4 cm. in length, was a ripe male. The testes were present in a series from the blunt tail to the anterior fifth of the body. The mouth was a large corrugated slit just behind the cephalic slits. The brain, which was situated just in front of the region where the cephalic slits widen out, showed through the ventral wall of the body and through the slits, laterally, as a bright red body.

Joubin regards this species as a variety of *C. marginatus*, but Bürger, who has obtained many specimens of both, is convinced of its validity, stating that all the forms which are pigmented in the manner characteristic of this species differ from *C. marginatus* in the structure of the brain.

I am not sure whether this species is included by McIntosh as a variety of *C. angulatus*. If not, this is its first record in Great Britain.

This is another of the deep water species, which are, no doubt, more common than they seem, but which are at present nearly inaccessible to us.

REFERENCES.

1. McIntosh, W. C.—*A Monograph of British Annelids.* Part I, Nemertines.
2. Hubrecht.—*Genera and Species of European Nemertines,* Notes from Leyden Museum, xliv.
3. „ *"Challenger" Report on Nemertea.*
4. Joubin.—*Sur les Turbellariés des Côtes de France,* Arch. Zool. exp. et gén., 2me série, viii, 1890.
5. Bürger.—*Ueber die Anatomie u. Histologie der Nemertinen nebst Beiträgen zur Systematik,* Z. f. w. Z., xv, 1890.
6. „ *Vorläufige Mittheilungen über Untersuchungen an Nemertinen des Golfes von Neapel,* Nachrichten v. d. K. Gesellschaft d. Wissenschaften zu Göttingen, 1891.
7. „ *Zur Systematik der Nemertinen fauna des Golfes Neapel,* ibid., March, 1892.
8. Carus, J. V.—*Prodromus Mediterraneæ.*
9. Barrois, J.—*L'Embryologie des Nemertes,* Paris, 1877.
10. Dieck.—*Anatomie u. Ontogenie der* Cephalothrix Galatheæ, Jenaische Zeitschrift, Bd. viii, 1874.
11. Du Plessis, G.—*Sur une nouvelle* Oerstedia *aveugle mais portant une paire de vésicules auditives,* Z. Anzeiger, 14 Jahrg., pp. 413–16, 1891.

The Turbellaria of Plymouth Sound and the Neighbourhood.

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I PROPOSE in this paper to furnish a list of the marine Turbellaria of Plymouth Sound and the neighbourhood, including all species that have hitherto been recorded from this locality. That such an attempt is in some respects premature I am only too well aware, but I have written it for the convenience of those who are working at, or are interested in, the fauna of Plymouth, and it may serve as a starting-point in our knowledge of the Turbellaria of the Sound. The synonymy and descriptions of the species are given by v. Graff, Lang, Jensen, and recently, together with figures of the new species and the literature, by myself.*

During August and September of 1892 I occupied a British Association table at the Laboratory, Plymouth, and commenced an investigation into the Turbellaria of the Sound. This was practically an unworked field. Montagu had indeed discovered *Prostheceræus vittatus* in Kingsbridge Estuary, South Devon, in 1815 : the Channel Islands have been partially explored with regard to the Turbellaria : St. Malo and St. Vaaste-la-Hogue have been still more carefully explored by Quatrefages, Keferstein, and Claparède. These researches, however, deal almost exclusively with the Polycladida. Hence it is only recently, through the investigations of Professor Hallez, that the Rhabdocœlida have received due attention at Wimereux and in the Strait of Dover. Professor Hallez's results are not yet quite complete, and I much regret my inability to consult the original papers.†

The general results of my observations may be here briefly summarised. As one might have expected, a number of Mediterranean forms were noticed (about 18 per cent.). These, together with certain Scandinavian and a few new species, form the additions to the fauna. I should state that for several reasons my attention was directed more particularly to the Rhabdocœlida, consequently the number of Polycladida here recorded will, in all probability, be increased by future investigation.

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* *British Marine Turbellaria,* Quart. Journ. Micros. Sci., April, 1893.

† Revue biologique du nord de la France, Lille, 1890–2.

As regards the methods of collecting the Turbellaria, it is necessary to bear in mind that almost all the Rhabdocœlida are so minute (rarely more than 2 mm. in length) as to render it a matter of the greatest difficulty to isolate them from the tangled masses of seaweed in which they are usually found. My method of working the area between tide-marks was twofold. I collected the *Ulva, Ptilota, Bryopsis,* and other weeds, and placed them in vessels of sea water in the Laboratory. The Rhabdocœles emerged in great numbers, especially towards night, and could be picked out with a pipette. Stones richly coated with ascidians, polyzoa, sponges, &c., and the sand- and shell-débris at the base of *Corallina,* treated in a similar manner, were very productive. The drawback to this method is that the real habitat of any particular species cannot thus be determined; and although I attempted to isolate the various kinds of seaweeds I was not successful in establishing a constant relation between a Turbellarian and the plant on which it is found.

My second method was that proposed to me by David Robertson, Esq. It consisted in the use of a hand-net, in the mouth of which a sieve was placed to prevent the entrance of bulky weeds. Such a net was used from the dinghy at low water among the *Laminaria, Halydris,* &c., which border the creeks in Wembury Bay, the Breakwater, and other places. Tide-pools were also explored by its help. The dredge brought up a large number of interesting forms. Millbay Channel, the Hamoaze, the Duke Rock, and the New Grounds are especially productive in infra-littoral forms. Examination of dredge-material at night gives one a vivid idea of the activity and voracity of this group. Pelagic forms were rare, and chiefly represented by the larvæ of Leptoplana and Müller's larvæ. The latter were specially abundant in October.

Distribution of Turbellaria in Zones of Depth.

First Zone.—This zone is usually uncovered for one to two days during neap-tides. *Monotus fuscus* is here the characteristic form, although it ranges throughout the tidal zone. It appears to derive moisture from Balani into which it creeps during ebb-tide. Other interesting devices for gaining moisture are recorded by Hallez and v. Graff. Towards the lower portion of this zone *Convoluta paradoxa* occurs.

SECOND OR MID-TIDAL ZONE.—This zone, daily covered by the tide, is characterised by the two species already mentioned, and also the following :—*Aphanostoma diversicolor, Byrsophlebs graffi, Provortex balticus, Macrorhynchus naegelii, Plagiostoma vittatum,* and *Vorticeros auriculatum.* Almost all these are provided with adhesive cells (Haftpapillen) at their posterior end, enabling them to retain their position during the wash of the tide.

THIRD ZONE.—Exposed during spring-tides. *Cylindrostoma quadrioculatum, Convoluta flavibacillum, Hyporhynchus armatus, Acrorhynchus caledonicus, Leptoplana tremellaris.* This zone marks the lower limit of the Acœla, and of the great majority of Rhabdocœla.

FOURTH ZONE.—Depths up to 20 fathoms. *Promesostoma solea, Provortex rubrobacillus, Cylindrostoma inerme, Plagiostoma girardi,* species of *Enterostoma, Stylostomum variabile, Oligocladus sanguinolentus, Eurylepta cornuta.*

This sketch of the zones must be regarded as purely tentative, since my stay was not sufficiently prolonged to enable me to test these results. I was led to attempt such a classification from the striking absence of Acœla and most Rhabdocœla below the Laminarian zone. On this subject there appears to be very little published work, and it would be a matter of some interest to ascertain the alterations in the vertical distribution of Turbellaria according to the difference of surroundings and tidal conditions at various parts of the coast.

LOCAL DISTRIBUTION OF TURBELLARIA.

Wembury Bay.

My work in this bay has been restricted to an examination of the well-known collecting-ground exposed at low water below Wembury Church. So far as my experience goes, this appears to be (for Turbellaria) the richest locality in the neighbourhood of Plymouth. Nineteen species have occurred between tide-marks excluding four doubtfully new forms, which were either too rare or too immature for exact and thorough determination.

It is not easy to define the characteristic Turbellarian features of Wembury Bay. The abundance of *Cylindrostoma quadrioculatum, C. inerme, Macrorhynchus naegelii,* and *Plagiostoma dioicum,* together with five species of the Acœla, and the apparent absence of Monotidæ, lend a provisionally distinctive aspect.

The splendid tide-pools abounding in such algæ as *Cystoseira ericoides, Codium tomentosum, Bryopsis plumosa,* are the best hunting-grounds. Among sand at the base of *Corallina officinalis,* curious colour-varieties of *Leptoplana tremellaris,* specimens of *Aphanostoma diversicolor, Convoluta paradoxa, Plagiostoma girardi* (at low spring-tides), and an example of what appears to be *Fovia affinis* (a marine Triclad). In the tufts of matted Florideæ which hang from the under surface of rocks, *Cylindrostoma quadrioculatum* occurs in hundreds. Tow-netting in the narrow creeks that run in between the rocks produced young specimens of *Leptoplana tremellaris, Convoluta paradoxa, Plagiostoma vittatum,* and *Cylindrostoma inerme.* Working the Laminaria-fronds by a hand-net from the stern of the "Anton Dohrn" did not, however, add anything of interest.

There can be no doubt that many forms have been overlooked, and that if examined earlier in the year, Turbellaria differing from those occurring during the summer might be found. The following is a list of the species hitherto recorded:

Polycladida, *Leptoplana tremellaris.*

Tricladida, *Fovia affinis.*

Rhabdocœlida.

ACŒLA, *Proporus venenosus, Monoporus rubropunctatus, Aphanostoma diversicolor, Convoluta paradoxa, C. flavibacillum.*

RHABDOCŒLA, *Promesostoma marmoratum, Acrorhynchus caledonicus, Macrorhynchus naegelii, Hyporhynchus armatus, Provortex balticus.*

ALLŒOCŒLA, *Plagiostoma dioicum, Pl. elongatum, Pl. vittatum, Pl. girardi, Enterostoma fingalianum, Cylindrostoma quadrioculatum, Cyl. inerme.*

Plymouth Breakwater.

Of the two faces of the Breakwater I have naturally paid most attention to the inner one, the stones and weeds of which afford good collecting-ground during low spring-tides. Many of the weeds on the inner face have, during the summer, an unhealthy, half-decayed appearance, which is associated with the occurrence of certain Turbellaria. *Pseudorhynchus bifidus,* however, which occurs typically in such a habitat in the Isle of Man and the east and west coasts of Scotland, has not yet occurred at Plymouth. *Macrorhynchus naegelii* and *Plagiostoma koreni* are the characteristic forms of the Breakwater. The number of adult examples of the former species diminished from the beginning of August onwards, and Mr. Garstang sent me the largest he could find in November, but all, without exception, were quite immature. Stones, the cavities of which were occupied by anemones, brought from the Breakwater and kept for some time (six weeks to two months) in the Laboratory, produced a number of *Plagiostoma vittatum* and *Pl. koreni*. The pyriform stalked egg-capsules of the former were deposited in numbers in August. These and other species have the habit of creeping about under a covering of diatom-deposit which encrusts stones, weeds, &c. Protected in this way they are extremely difficult to find.

My method of examining the Breakwater was chiefly the use of a hand-net, which was worked vigorously among the weeds at low water from the dinghy. By this means the following fauna were obtained:

Polycladida, *Leptoplana tremellaris* (adult and young).

Rhabdocœlida.

Acœla, *Aphanostoma diversicolor.*

Rhabdocœla, *Macrorhynchus naegelii, Mesostoma* (?) *neapolitanum.*

Allœocœla, *Plagiostoma elongatum, Pl. koreni, Pl. vittatum, Vorticeros auriculatum* and *V. luteum, Allostoma pallidum, Monotus lineatus.*

Cawsand Bay.

There are here two distinct collecting-grounds—the rocks and tide-pools exposed at low water on the north side of the bay towards Picklecombe Fort, and the beds of Zostera that grow on the sandy bottom. In the former locality *Acrorhynchus caledonicus* is the prevailing species, as *Hyporhynchus armatus* is the chief feature of the Zostera bed. It was only toward the end of my visit that I discovered the tiny Rhabdocœles among the Crustacea and Nemertea which occur in great quantity in the Zostera, so that many forms will probably be added by a re-examination of the dredgings taken among the rich weedy ground indicated by Prof. Johnson (the Journal [N. S.], I, iii, pp. 297–8).

In the following list Z refers to species inhabiting the Zostera beds, N to forms occurring in the rock-pools on the north side of the bay.

Polycladida, *Oligocladus sanguinolentus* (Z).

Rhabdocœlida.

Acœla, *Proporus venenosus* (Z), *Monoporus rubropunctatus* (Z), *Convoluta saliens* (Z), *C. paradoxa* (N), *C. flavibacillum* (Picklecombe Fort).

Rhabdocœla, *Promesostoma solea* (Z), *P. agile* (Z), *Proxenetes flabellifer* (N), *Acrorhynchus caledonicus* (N), *Hyporhynchus* *armatus* (Z), *H.* (?) *penicillatus* (Z), *Provortex affinis* (N), *P. rubrobacillus* (Z).

ALLŒOCŒLA, *Plagiostoma vittatum* (N and Z), *P. dioicum* (N), *P. girardi* (N), *Monotus albus* (N).

New Grounds.

The Turbellaria of this part of the Sound (north of the west entrance to the Sound), like the flora, is similar to that of the Duke Rock. There is, however, a characteristic form (*Provortex rubrobacillus*) that has not occurred elsewhere in the neighbourhood. *Macrorhynchus croceus* and *M. helgolandicus* will probably be found in other parts of the Sound, although at present this is the only known locality for them.

Polycladida, *Leptoplana tremellaris.*

Rhabdocœlida.

RHABDOCŒLA, *Promesostoma solea, Macrorhynchus naegelii, M. croceus, M. helgolandicus, Provortex rubrobacillus.*

ALLŒOCŒLA, *Plagiostoma vittatum, Vorticeros luteum, Cylindrostoma inerme.*

Duke Rock.

The Duke Rock, situated in 7 fathoms at the east entrance of the Sound, forms one of a number of dredging-grounds inside the Sound, the Turbellarian fauna of which has a common general facies. The conditions of life in these localities are different from those in the tidal zone, and the difference is expressed in the Turbellaria as well as in other groups of animals and plants. Thus Acœla are, so far as my experience goes, quite unrepresented; the Allœocœla, on the other hand, are abundant.

The Turbellaria of the Duke Rock closely resemble those of the New Grounds, and this similarity is also borne out in the flora (see Johnson, "Flora of Plymouth Sound," loc. cit., p. 291). The most interesting form was a single specimen of *Monoophorum striatum* (Böhmig) (= *Enterostoma striatum*, v. Graff), which has hitherto only occurred at Trieste. Its carmine colour and the appearance of the muscles grouped in longitudinal bundles at once attract attention.

Species of the genus *Enterostoma* (perhaps at present the most unsatisfactory genus of all Allœocœla) are abundant here and elsewhere in the Sound. As, however, I have not completed my revision of the genus, the species recorded are only part of those that were actually found. The following is a list of the Duke Rock Turbellaria:

Polycladida, *Leptoplana tremellaris, Eurylepta cornuta, Stylostomum variabile.*

Rhabdocœlida.

Rhabdocœla, *Promesostoma ovoideum, Pr. solea.*

Allœocœla, *Plagiostoma dioicum, Pl. girardi, Enterostoma austriacum, Cylindrostoma inerme, Monoophorum striatum, Automolos unipunctatus.*

Drake's Island.

The well-known collecting-ground on the north-eastern face of this locality has furnished the following fauna. The great belt of Laminaria extending in the direction of the Breakwater did not add anything of interest.

Polycladida, *Leptoplana tremellaris,* adult and young (3 mm. long).

Rhabdocœlida.

Acœla, *Proporus venenosus, Monoporus rubropunctatus, Convoluta paradoxa.*

Rhabdocœla, *Promesostoma marmoratum, Pr. solea, Pr. agile, Byrsophlebs intermedia, Byr. graffi, Acrorhynchus caledonicus, Macrorhynchus naegelii* (Claparède's variety with dorsal yellow streak), *Provortex affinis.*

Allœocœla, *Plagiostoma vittatum, Vorticeros auriculatum, Cylindrostoma quadrioculatum* (also on the S.E. face of the island).

Redding Point.

By this locality I include the shore from Redding Point to northward under Mount Edgcumbe Park. This area is prolific in littoral forms, the tide-pools and rocks being covered with a profusion of animal and vegetable life. *Promesostoma marmoratum, Monotus fuscus,* and *M. lineatus* are the prevalent forms, the two latter species being particularly abundant among the *Ulva* that covers the stones. The use of a hand-net in the tide-pools needs some discretion, since the crustacean *Virbius varians* swarms to such an extent as to exclude almost everything else. To get over this difficulty it is necessary to employ a fine sieve, as described in the introduction.

A comparison of the Turbellarian fauna with that of other parts of the Sound cannot yet be made justly, as my investigations are not yet sufficiently complete. The Turbellaria appear to resemble those of the Breakwater, as a comparison of the accompanying tables tends to show. Specially interesting forms are *Aphanostoma elegans*, hitherto recorded from Bergen, and *Plagiostoma sagitta*, found by Uljanin in the Bay of Sebastopol. The occurrence of species from such widely distant localities shows how much still remains to be done before we can determine the geographical distribution of the species of this group.

The following list of species were taken at low water round Redding Point and northwards :

Polycladida, *Stylostomum variabile* (·75 mm. long).

Rhabdocœlida.

ACŒLA, *Convoluta paradoxa, Aphanostoma elegans.*

RHABDOCŒLA, *Microstoma grœnlandicum, Promesostoma marmoratum, Pr. solea, Acrorhynchus caledonicus, Macrorhynchus naegelii, Hyporhynchus armatus, Provortex balticus.*

ALLŒOCŒLA, *Plagiostoma vittatum, Pl. koreni, Pl. sagitta, Vorticeros auriculatum, Monotus lineatus, M. fuscus.*

East Side of the Sound.

Under this heading I include the rocks below the Laboratory, Rum Bay, Batten Bay, and Bovisand Bay. As regards the Turbellaria of the first three there is little to be said. The same causes that have impoverished the flora and fauna probably account for the poor result in this group. Repeated attempts only resulted in *Convoluta paradoxa, Plagiostoma vittatum, Vorticeros auriculatum,* and *Monotus fuscus.* The last also occurs on the rocks below the ladies' bathing-place. In Bovisand Bay the tide-pools yielded *Convoluta paradoxa* and *C. flavibacillum.*

The Hamoaze.

A portion of this locality was explored by the help of the "Firefly." The stones and débris that are brought up are covered with the mud-tubes of *Polydora cæca*, tenanted, however, by an Amphipod, *Corophium Bonellii.* The great abundance of this Crustacean possibly in part accounts for the limited Turbellarian fauna.

Polycladida, *Leptoplana tremellaris.*

Rhabdocœlida.

ALLŒOCŒLA, *Plagiostoma pseudomaculatum, Cylindrostoma inerme, Automolos (?) ophiocephalus, Aut. horridus.*

Millbay Channel.

This channel (varying in depth from 18 to 21 fathoms) is a recognised locality for certain animals, and I have found some species of Turbellaria peculiar to it. The allœocœlous fauna of this channel and the Hamoaze present an interesting species of the genus *Automolos,* apparently connecting the Allœocœla with the Tricladida. More observations are however needed, and an examination of these two localities will probably forward the solution of this problem. Species of *Cylindrostoma* and *Enterostoma* make up the bulk of the fauna. A specimen of what I take to be *Plagiostoma siphonophorum* (if confirmed) will prove to be another Adriatic form added to the Plymouth fauna.

Polycladida, *Leptoplana tremellaris* (abundant), *Oligocladus sanguinolentus, Stylostomum variabile* (young stages, ·5—1 mm., are not uncommon in September).

Rhabdocœlida.

Rhabdocœla, *Promesostoma solea.*

Allœocœla, *Plagiostoma siphonophorum* (?), *Pl. girardi, Enterostoma fingalianum, E. austriacum, Automolos ophiocephalus.*

SYSTEMATIC LIST OF THE TURBELLARIA.*

TURBELLARIA.

Sub-order 1.—RHABDOCŒLIDA.

A. *ACŒLA.*

Family PROPORIDÆ.

Genus 1.—Proporus.

1. Proporus venenosus (O. Schmidt).

This species is readily distinguished from all other Acœla by its elongate form, yellow colour, and large eyes. It is not uncommon at the base of the littoral zone at Wembury Bay and Drake's Island.

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* A key for the determination of genera and species may be found in my "British Marine Turbellaria," loc. cit., pp. 514—522.

Genus 2.—MONOPORUS.

2. MONOPORUS RUBROPUNCTATUS (O. Schmidt).

Found in the same localities as the foregoing. Both are Mediterranean species.

Family APHANOSTOMIDÆ.

Genus 3.—APHANOSTOMA.

3. APHANOSTOMA DIVERSICOLOR Oersted.

In various localities between tide-marks. Not uncommon in the diatom-deposit on the sides of the tanks in the aquarium.

4. APHANOSTOMA ELEGANS Jensen.

A single specimen amongst *Ulva* at Redding Point.

Genus 4.—CONVOLUTA.

5. CONVOLUTA SALIENS v. Graff.

This species is apparently rather rare at Plymouth. Among Zostera from Cawsand Bay is the habitat for it. The curious mode of progression by sudden leaps, which co-exists along with the usual method of continuous movement, was first described by v. Graff in his "Monograph," and is apparently unique.

6. CONVOLUTA PARADOXA Oersted.

Widely distributed in the littoral zone; nowhere, however, very abundant, nor do the specimens attain the dimensions of Millport examples.

7. CONVOLUTA FLAVIBACILLUM Jensen.

Among sand in the creeks at Picklecombe Fort, Wembury Bay, and Bovisand Bay.

B. *RHABDOCŒLIDA.*

Family MICROSTOMIDÆ.

Genus 5.—MICROSTOMA.

8. MICROSTOMA GRŒNLANDICUM Lev.

Among Ulva, Redding Point.

Family MESOSTOMIDÆ.

Genus 6.—PROMESOSTOMA.

9. PROMESOSTOMA MARMORATUM (Schultze).

Variable in coloration and in the form and dimensions of the crosier-like copulatory organ. Not uncommon in tide-pools in Wembury Bay, Drake's Island, and Redding Point.

10. PROMESOSTOMA OVOIDEUM (O. Schmidt).

Occasionally dredged near the Duke Rock.

11. PROMESOSTOMA SOLEA (O. Schmidt).

Abundant in dredging taken from almost all localities.

12. PROMESOSTOMA AGILE (Levinsen).

Among *Zostera* in Cawsand Bay.

Genus 7.—BYRSOPHLEBS.

13. BYRSOPHLEBS GRAFFI Jensen.

Drake's Island, low spring-tide. Amongst algæ.

14. BYRSOPHLEBS INTERMEDIA v. Graff.

In the same locality as the foregoing.

Genus 8.—PROXENETES.

15. PROXENETES FLABELLIFER Jensen.

In tide-pools on the north side of Cawsand Bay.

Genus 9.—MESOSTOMA.

16. MESOSTOMA NEAPOLITANUM v. Graff (?).

A single specimen obtained among *Fuci* bordering the inner side of the Breakwater. This species hitherto recorded only from the Mediterranean.

Family PROBOSCIDÆ.

Genus 10.—ACRORHYNCHUS.

17. ACRORHYNCHUS CALEDONICUS (Claparède).

Found in abundance among Fucus, Halydris, &c., in tide-pools near Picklecombe Fort and Redding Point; less commonly in Wembury Bay.

Genus 11.—MACRORHYNCHUS.

18. MACRORHYNCHUS NAEGELII (Kölliker).

On the inner side of the Breakwater at low spring-tides this species was found plentifully during August.

19. MACRORHYNCHUS CROCEUS (Fabricius).

Dredged on one occasion on the "New Grounds."

20. MACRORHYNCHUS HELGOLANDICUS (Metschnikoff).

In the same locality as the foregoing. Probably a search instituted earlier in the year would reveal more localities for these two species. Only a few adults were found, usually each with a single egg-capsule.

Genus 12.—HYPORHYNCHUS.

21. HYPORHYNCHUS ARMATUS (Jensen).

Abundant among *Zostera* in Cawsand Bay and in tide-pools at Redding Point.

22. HYPORHYNCHUS PENICILLATUS (Schmidt).

A single specimen among Zostera, Cawsand Bay.

Family VORTICIDÆ.

Genus 13.—Provortex.

23. Provortex balticus (Schultze).

This species is apparently not common at Plymouth during August and September. It occurs between tide-marks, most commonly in Wembury Bay.

24. Provortex affinis (Jensen).

Among algæ on the north- and south-eastern faces of Drake's Island.

25. Provortex rubrobacillus, Gamble.

This form is figured and described in my "British Marine Turbellaria," pp. 470–1, pl. xxxix, fig. 8, and pl. xl, fig. 12. The constant presence of red, rod-like concretions in the intestinal cells and the form of the copulatory organ are diagnostic features.

C. *ALLŒOCŒLA.*

Family PLAGIOSTOMIDÆ.

Genus 14.—Plagiostoma.

26. Plagiostoma dioicum (Metschnikoff).

Duke Rock and Wembury Bay.

27. Plagiostoma elongatum Gamble ("British Marine Turbellaria," p. 473).

A single specimen among sand, Wembury Bay. Mr. Garstang sent me two from the Breakwater in November.

28. Plagiostoma pseudomaculatum Gamble (loc. cit., p. 474).

Among the weed-tubes of *Polydora cæca* in the Hamoaze.

29. Plagiostoma sagitta Uljanin.

Among weeds in a tide-pool, Redding Point.

30. Plagiostoma caudatum Levinsen.

A single specimen dredged in Cawsand Bay among *Zostera*.

31. PLAGIOSTOMA VITTATUM (Frey u. Leuckart).

An abundant littoral species in all localities. The variations in colour are great, and are discussed by v. Graff and myself. Egg-capsules were obtained from the Breakwater in September.

32. PLAGIOSTOMA KORENI Jensen.

Among algæ on the Breakwater and at Redding Point, also among diatom-deposit in the tank-room of the Laboratory.

33. ? PLAGIOSTOMA SIPHONOPHORUM (Schmidt).

A specimen in the Millbay Channel. (See "Brit. Mar. Turbellaria," p. 477.)

34. PLAGIOSTOMA GIRARDI (Schmidt).

At extremely low spring-tide, Wembury Bay, and in tide-pools on the north side of Cawsand Bay. Not uncommon on the Duke Rock and in Millbay Channel.

Genus 15.—VORTICEROS.

35. VORTICEROS AURICULATUM (O. F. Müller).

Found in the same localities and under the same conditions as *Plagiostoma vittatum*.

36. VORTICEROS LUTEUM v. Graff.

A single specimen dredged off the New Grounds; another obtained on the inner side of the Breakwater.

Genus 16.—ENTEROSTOMA.

37. ENTEROSTOMA AUSTRIACUM v. Graff.

Specimens referable to this species occurred commonly in the Sound at depths below 5 fathoms.

38. ENTEROSTOMA FINGALIANUM Claparède.

Among *Florideæ*, Wembury Bay.

Genus 17.—CYLINDROSTOMA.

39. CYLINDROSTOMA QUADRIOCULATUM (R. Leuckart).

Abundant in the same locality as the preceding.

40. Cylindrostoma inerme (Hallez).

In dredgings taken from the Duke Rock, Millbay Channel, and the Hamoaze.

41. Cylindrostoma elongatum Levinsen.

Tide-pools, Wembury Bay.

Genus 18.—Monoophorum.

42. Monoophorum striatum (v. Graff).

A single specimen of this characteristic species was dredged off the Duke Rock.

Family MONOTIDÆ.

Genus 19.—Monotus.

43. Monotus lineatus (O. F. Müller).

Not uncommon amongst *Ulva* in the neighbourhood of Redding Point.

44. Monotus fuscus (Oersted).

Abundant among *Balani, Ulva,* and generally throughout the littoral zone.

45. Monotus albus Levinsen.

In tide-pools below Picklecombe Fort.

Genus 20.—Automolus.

46. Automolus unipunctatus (Oersted).

Rarely amongst algæ, Duke Rock.

47. Automolos horridus Gamble ("British Marine Turbellaria," p. 491).

A single specimen in the Hamoaze.

48. (?) Automolos ophiocephalus (Schmidt).

Millbay Channel. For a discussion of the probable relations of this form see my paper, pp. 492–3.

Sub-order 2.—TRICLADIDA.

Family PLANARIIDÆ.

Genus 21.—FOVIA.

49. FOVIA AFFINIS Stimpson.

In a sandy creek, Wembury Bay.

Sub-order 3.—POLYCLADIDA.

A. *ACOTYLEA.*

Family PLANOCERIDÆ.

Genus 22.—LEPTOPLANA.

50. LEPTOPLANA TREMELLARIS (O. F. Müller).

I have recently ascertained that many examples grouped under this species, on the ground of their general agreement with the type in form, colour, and the number and position of the eye-groups, in reality belong to the next species. The subject requires further investigation, which, owing to the pressure of other work, I am unable to undertake at present. The specific characters and synonymy of this form are given fully by Lang in his "Polycladida," and the previous records on our coast in my "British Marine Turbellaria."

Adult examples occur generally at Plymouth, under stones and shells from the littoral zone down to 15 fathoms. They are plentiful during July and August, becoming scarcer in September. Mr. Garstang informs me that the species during February is difficult to discover even in its summer haunts. It is tolerably certain that, like the majority of littoral animals, the adults die in the autumn, and the young probably attain sexual maturity in the following summer.

Copulation in this species has not hitherto been observed. The eggs are laid in successive batches, surrounded by an albuminous substance. They adhere to stones, algæ, &c., between tide-marks, and after a period varying from a fortnight (Keferstein) to two months (Hallez) the larvæ hatch out. Specimens 1 to 3 mm. in length, and having the outline of a spherical triangle, were fairly abundant in the littoral zone in September. Thus at Wembury Bay and inside the Breakwater many specimens were obtained with the aid of the hand-net among *Laminaria, Corallina,* &c. A few specimens also occurred in tow-nettings taken close inshore and also in mid-channel, outside the Breakwater. At present I am unable to state whether these young *Leptoplana* belong to either or both of the species here recorded. The genital ducts afford the only secure diagnostic features, and naturally these are wanting in the present instance.

51. Leptoplana Drœbachensis Oersted.

In my paper previously cited I have discussed the possible identity of this species with the older *L. atomata,* O. F. M.

Recently, specimens from Plymouth Sound have reached me which agree in almost every particular with *L. Drœbachensis,* Oe., as described by Jensen, and it appears probable that this species has hitherto been confused on our coasts with *L. tremellaris.* The old species, *L. atomata,* O. F. M., whose relations with other species of the genus are totally obscure, might perhaps be dropped altogether.

B. *COTYLEA.*

Family EURYLEPTIDÆ.

Genus 23.—Prostheceræus.

52. Prostheceræus vittatus (Montagu).

This fine species, discovered by Montagu in the estuary of Kingsbridge, has occurred off Stoke Point on *Diazona* in 15 fathoms (Mr. Cunningham), and also in the Sound (Mr. Garstang).

Genus 24.—Cycloporus.

53. Cycloporus papillosus Lang.

Infra-littoral specimens have occurred on ascidians and sponges (*e. g. Hymeniacidon sanguinea*) dredged in the Cattewater, and also outside the Sound. The variety *lævigatus* occurred along with *Stylostomum variabile* (to which it bears no little resemblance) in the river Yealm in October. The relations which appear to exist between this species and the substratum in which it lives are discussed by me in the forthcoming number of the Transactions of the Liverpool Biological Society.

Genus 25.—EURYLEPTA.

54. EURYLEPTA CORNUTA (O. F. Müller).

Occasionally dredged on the Duke Rock and in the estuary of the Yealm.

Genus 26.—OLIGOCLADUS.

55. OLIGOCLADUS SANGUINOLENTUS (Quatrefages).

Adult specimens were dredged off the Duke Rock, Millbay Channel, Cawsand Bay, and Stoke Point.

Genus 27.—STYLOSTOMUM.

56. STYLOSTOMUM VARIABILE Lang.

Estuary of the Yealm, Duke Rock. Young stages were found between tide-marks at Redding Point and round the Mallard Buoy in September.

The Post-larval Stage of Arenicola marina.

By

Wm. Blaxland Benham, D.Sc.Lond.,
Aldrichian Demonstrator of Anatomy in the University of Oxford.

With Plate I.

By "post-larval stage" I wish to indicate that stage in the developmental history of *Arenicola* at which the full adult number of somites has appeared, and the body is already distinguishable into (*a*) an anterior chætigerous region, and (*b*) a posterior achætous region or tail, but in which the gills are not yet completely formed or have not yet even made their appearance.

Such a stage was sent to me early in March, 1893, by Mr. Garstang, with a suggestion, which turned out to be perfectly well founded, that the worms were the young of *Arenicola*.

My hearty thanks are herewith accorded to him for his kindness in giving me the opportunity of studying them.

Two of these small worms were collected, one on February 22nd, the other on the 23rd of the same month, and he sent them to me preserved. One was stained and mounted entire, the other was cut into sections, partly longitudinal, partly transverse. An unfortunate accident to the longitudinal sections deprived me of investigating the anterior end of the worm as thoroughly as I could have wished, and though Mr. Garstang has been constantly on the look-out for more specimens, success has not crowned his efforts.

Mr. Garstang gives me the following information as to these larvæ:—"Each was inhabiting a perfectly colourless and transparent gelatinous tube, obviously secreted by itself. The body of the *Arenicola* larva was very flexible when alive, enabling it to wriggle actively in an eel-like manner in the water—generally near the surface—when placed in a tall clear glass jar."

"The two extremities of the body were in each of the larvæ yellow. This yellow colour was due to a number of yellow bodies or cells apparently situated in the epidermis. The blood was distinctly reddish."

"The gelatinous tube seemed to invest the body closely, and was certainly no impediment to the animal."

These two specimens are practically identical.

The worm is about 6·8 millimetres in length. It consists of a prostomium, without eye-spots, but with a light area or depression on each side in which is lodged the otocyst, followed by a peristomium and twenty chætigerous somites forming the anterior region, with a tail of a greater number of somites—some thirty or more—terminating in a small pygidium or anal somite.

These tail somites are difficult to enumerate, as the septa are not well developed, but each segment is surrounded by a band of gland-cells, which serve for their demarcation.

The worm is surrounded by a structureless gelatinous-looking envelope or tube (figs. 1, 4), probably secreted by these gland-cells, which are not confined to the tail, but occur in every somite; in fact, they are more abundant in the anterior somites, and here occur in two bands per somite, separated by a narrow non-glandular band (see fig. 7). This closely investing gelatinous tube seems, when taken in connection with sundry internal arrangements, such as nephridia, septa, &c., to point to an affinity with the *Chlorhæmidæ*.

As will be seen from the accompanying figures (fig. 1), the dorsal bundle contains two long capillary chætæ, of which one is longer than the other.

The peristomium is achætous; the first dorsal bundle is represented by a minute dorsal chæta (*Ch.* 2), scarcely protruding from the body, in Somite 2. At first sight the entire region between the prostomium and the first long chæta appears to be achætous, but this region is divided into two portions by a slight groove ventrally, and careful observations showed this small chæta (*Ch.* 2, fig. 1), demonstrating the composition of this region. In the adult *Arenicola* the achætous region following the prostomium has been regarded on other grounds—to wit, the existence of two septa anterior to the first bundle of chætæ—as being composed of two somites.

This small chæta, then, probably disappears in the adult, as has been shown to be the case with the anterior chætæ in some other Polychætes.

The ventral chætæ commence in Somite 3; they are much shorter than the capillary chætæ, being only about twice the length of the thickness of the body-wall. Each chæta is a sigmoid hook, with a small but distinct notch (fig. 2), the lower prong being the larger.

In the first few bundles there are only three chætæ; the number increases as we pass backwards, till in the hinder somites eight or nine chætæ constitute a bundle. Both the dorsal and ventral chætæ differ from those occurring in the adult, in which the dorsal chætæ present a series of small processes on each side (see Cunningham, Trans. Ed. Roy. Soc., xxxiii, 1888); whilst the ventral ones, as my fig. 3 shows, are without the smaller prong. Naturally the size of the chætæ differs, some idea of which difference will be conveyed by a comparison of figs. 2 and 3.

Of the thirteen pairs of gills in the adult, the present post-larval stage shows in profile only six pairs, situated on Somites 14—18. But I believe I can detect other gills on succeeding somites in the mounted specimen; however, it is difficult to be certain of the number. In the adult the first gill, which is quite small, occurs on the ninth somite (seventh chætigerous), and the last in the nineteenth chætigerous (*i. e.* the twenty-first somite). Thus the gills make their appearance from behind forwards. Each gill is at present merely a small somewhat conical papilla or eversion of the epidermis, containing a potential cavity entirely occupied by a looped blood-vessel (see fig. 5). The appearance suggests that these gills of *Arenicola* are special structures, and not, as in *Eunice* and other free-living Polychætes, modifications of the dorsal cirrus, as there is no trace of sensory hairs, which are present even in quite early stages in the development of cirri—for instance, in *Polydora.*

The epidermis is at this stage a single layer of cells, and varies, as it does in the adult, in different parts of the somite. In the non-glandular band (figs. 4 and 7) the cells whose outlines are not recognisable are flattened, and the nuclei are oval with their long axes parallel with the surface of the body. In the glandular band, however, the epidermis is thicker (fig. 5), and consists of narrow, deeply staining cells, compressed between large gland-cells. The nuclei of the former are small and circular, and of the latter compressed against the side of the cell. Viewed from above, the epidermis presents the appearance of fig. 7.

Wirèn (Kongl. Svensk. Vet. Akad. Handlingar, 22, pl. i, figs. 1—23) has described a similar difference in the epidermis cells between the ridges and those constituting the ridges in the adult. Probably these glandular bands of the post-larval stage become broken up into the polygonal areas or ridges of the adult.

I would here call attention to the strongly marked grooves, each followed by a distinct ridge, in the anterior somites; in this ridge the chætæ are inserted. This is true of both the post-larval stage and of the adult, and one would at first sight regard these grooves as intersegmental grooves, so that the chætæ appear to have the rather abnormal position of the anterior margin of the somite. But such is not in reality the case; dissections of the adult, as well as observation of the nephridia of this present stage, indicate that the chætæ, and thus the ridge and groove, are in the middle of the somite, for in the anterior regions of the adult are certain complete septa, the last of which is placed midway between the third and fourth bundles of chætæ, the next anterior midway between the second and third bundles. The anterior end of the nephridium in the somites containing these organs lies about midway between consecutive bundles of chætæ—where, in fact, the septum would occur. I am unable to distinguish the septa in the present mounted specimen.

Of internal structures I will draw attention more particularly to the vascular system. Wirèn (loc. cit., p. 38, et seq.) has shown that in the adult *Arenicola* the dorsal and ventral blood-vessels are merely local enlargements of a continuous perienteric sinus, from which the axial portions are slightly nipped off. *Now at this post-larval stage I find no sinus.* Both the dorsal and the ventral vessels are quite distinct from the wall of the gut, as the camera drawing (fig. 4) shows. From these axial vessels branches pass right and left to the wall of the gut (diagrammatically shown in fig. 8), where they subdivide to a slight extent, and give rise to a but feebly developed plexus below the cœlomic epithelium.

I have already, in discussing the perienteric blood-sinus of certain earthworms,* referred to the improbability of its being a primitive feature, as is sometimes held. Here in *Arenicola*, at any rate, we have a network preceding ontogenetically the sinus of the adult.

Other vessels pass to the gill as shown; the dorso-branchial vessel passes straight to the gill, curves round at the apex of the latter, and after two or three twists passes to the ventral vessel. Another vessel passes to the nephridium, but I have not traced its origin. The blood-vessels are covered by cœlomic epithelium, which, in the case of the ventral trunk and the ventro-branchial vessel, consists of rounded cells with brownish granular contents and a round nucleus; they are, in fact, chloragogic cells: elsewhere the cœlomic epithelium is flat.

In the body-wall the circular muscles are already present, and the epidermis rests directly upon them—the subepidermic tissue described by Wirèn has not yet made its appearance.

The longitudinal muscles are interrupted at three points, ventrally at the nerve-cord and dorso-laterally at the level of the dorsal chætæ. The oblique muscles so characteristic of Polychæta are attached at these same points (see fig. 4).

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* Quart. Journ. Mic. Sci., xxxiv, *A New English Genus of Aquatic Oligochæta* (Sparganophilus).

As to the separate existence of a somatic cœlomic epithelium I feel some doubt; apparently the inner ends of the cells giving rise to the longitudinal muscles are themselves the lining of the cœlom, so that these cells are *myocœlomic*.

The *nephridia* are confined to Somites 6—10, though there may be traces of them in other somites. I believe I can distinguish a small one, for instance, in Somite 5. They have thus the same position as in the adult, where they occur in the fourth to eighth chætigerous somites, *i. e.* Somites 6—10.

But though they have the same position, they are very different in shape. I have previously figured this organ in the adult (Quart. Journ. Mic. Sci., xxxii, pl. xxv, *The Nephridium of Lumbricus, &c.*), and the present fig. 6 may be compared therewith. In place of the great wide sac there is in the post-larval stage quite a simple narrow tube, running nearly in a straight line from the nephridial pore, situated behind the ventral bundle of chætæ, forwards to the nephrostome, about midway between that bundle and the preceding one. The tube is, however, divisible into two regions, according to the presence or absence of concretions. The former (fig. 6, *a*) forms rather more than half the whole length of the tube. The organ is ciliated throughout.

The nephrostome is perfectly simple, so far as I can judge; is without lips, so that we cannot speak of a "funnel" in the usual sense of the word.

With regard to the alimentary tract, it presents exactly the same regions as in the adult. The narrow œsophagus passes back from the pharynx (? if this is eversible) into a wide "stomach," occupying Somite 7 and part of 8. Into the hinder part of this a pair of cone-like diverticula open, each diverticulum being longitudinally ridged internally. Immediately after the stomach the gut presents a series of pouches on each side, as in the adult. This sacculated region extends through four or five somites, and is succeeded by the narrow intestine, which suddenly dilates in the "tail," and here occupies nearly the whole cavity of the body.

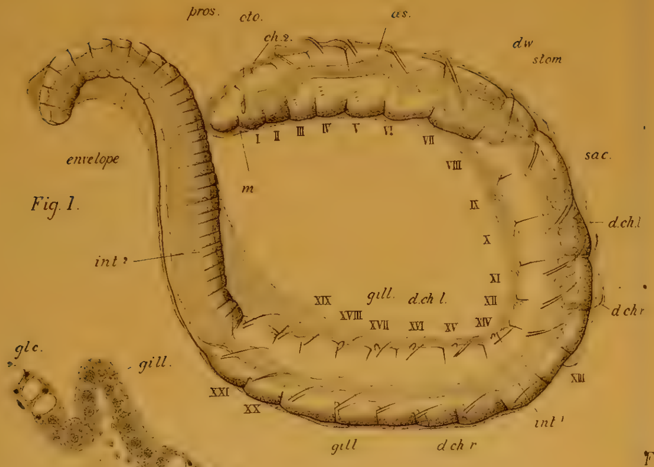
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Fig. 1.

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Fig 5

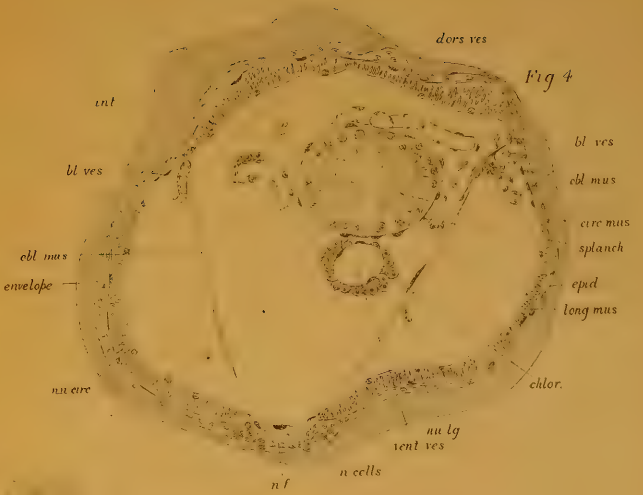
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Fig 4

Fig. 2

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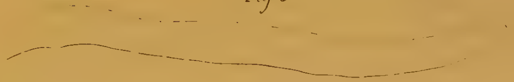

Fig 3

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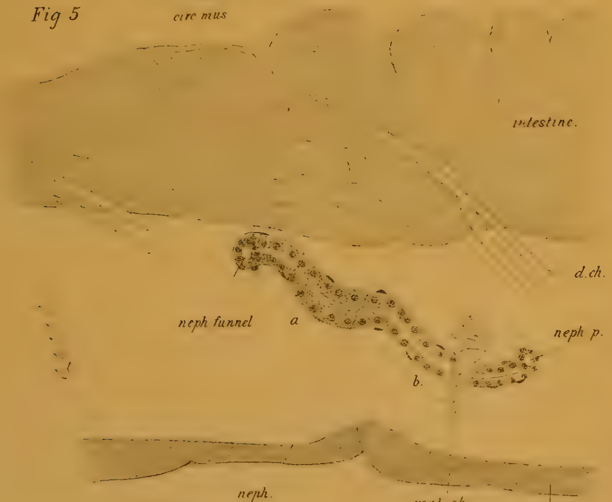
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Fig 6

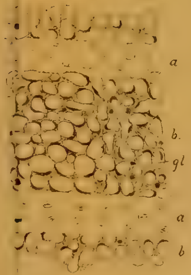

Fig. 7.

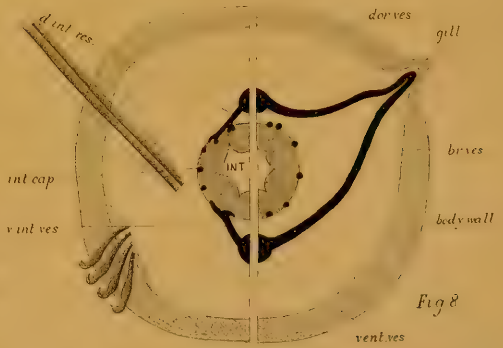
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Fig 8

W. B. Benham del.

J E Wood. Plymth

DESCRIPTION OF PLATE I,

Illustrating Mr. Benham's paper on "The Post-larval Stage of *Arenicola marina.*"

Fig. 1.—View of the larva mounted whole (from a camera drawing, under Zeiss *aa*, occ. 2). × 38. The animal is lying on its right side anteriorly, but is twisted in Somite 13, so that it presents its dorsal surface upwards. The dorsal chætæ of the right side are seen as far forwards as Somite 8. The ventral chætæ are seen anteriorly, but have not been represented after Somite 13. The rudimentary gills are seen in Somites 14 to 21. The somites in the "tail" are indistinct except towards the anus. The dark shading round the animal represents the structureless envelope secreted by it. *Ch.* 2. Rudimentary dorsal chæta of Somite 2. *div.* The diverticulum of stomach of the left side. *d. ch. l.* The dorsal chætæ of the left side. *d. ch. r.* The dorsal chætæ of the right side. *int'.* Narrow intestine. *int*^{2}. Wide intestine. *m.* Mouth. *œs.* Œsophagus. *oto.* Area deprived of pigment, below which is situated the otocyst. *Pros.* Prostomium. *sac.* Sacculated region of intestine. *stom.* Stomach.

Fig. 2.—One of the ventral chætæ from a transverse section. (Camera, Zeiss D. 4.) × 500.

Fig. 3.—One of the ventral chætæ of an adult *Arenicola.* (Camera, Zeiss B. 4.) × 150.

Fig. 4.—Transverse section through middle region of the body, about Somite 16. (Camera, Zeiss D. 2.) × 200. [The intestine has probably shifted a little from its natural position. The oblique muscles are not cut through in the section drawn, but I have added them from neighbouring sections.] *Bl. ves.* Blood-vessels passing to and from the gill (which is not represented in the section). *chlor.* Chloragogen cells around the ventral blood-trunk. *circ. musc.* Circular muscle of the body-wall. *dors. v.* Dorsal blood-trunk. *epid.* Epidermis. *int.* Intestine. *long. mus.* Longitudinal muscles of the body-wall. *n. cells.* Nerve-cells. *n. fi.* Nerve-fibres. *nu. circ.* Nuclei of circular muscles. *nu. long.* Nuclei of longitudinal muscles. *obl. mus.* The oblique (or transverse) muscle. *splanch.* Nuclei of visceral cœlomic epithelium. *vent. ves.* Ventral blood-trunk.

Fig. 5.—A section through a gill. *ep.* Epidermis, in which is a number of gland-cells (*gl. c.*). *circ. mus.* Circular muscles of the body-wall. *Bl. ves.* Branchial vessels.

Fig. 6.—A portion of Fig. 1 more highly magnified. It represents one of the somites containing a nephridium. (Camera, Zeiss D. 2.) × 200. The body-wall and the intestine are represented by the shading. The chætæ of two neighbouring somites are included in order to show the relative position of the nephridial pore and funnel. *a.* The excretory region. *b.* The "duct."

Fig. 7.—A portion of the body-wall viewed from the surface; it shows one of the glandular bands (*b*) bounded by the narrow non-glandular rings (*a, a*) which occur in each somite. *gl.* Gland-cells.

Fig. 8.—Diagrammatic transverse sections of the body to show vascular system in the branchial region on the right side, and the intestinal vessels on the left side. *Br. ves.* Branchial vessel. *Dor. ves.* The dorsal trunk. *Vent. ves.* Ventral trunk. Both are quite separate from the wall of the intestine (see Fig. 4). *d. int. ves., v. int. ves.* Vessels passing from these trunks to and from the plexus in the wall of the intestine (*int. cap.*).

The Immature Fish Question.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

I. STATISTICS.

It is only eight years since the Royal Commission on beam trawling issued its report, and already a Select Committee of Parliament has been appointed to make a new inquiry into one of the principal subjects investigated by that Commission, namely, the decrease of the fish supply and the advisability of remedial measures. Among the conclusions of the Commission was this one :

"That in the absence of a proper system of fishery statistics and scientific observations, it is impossible to measure the fluctuations of the fisheries or to discover their causes."

In consequence of this statement the Board of Trade began the collection and publication of fishery statistics in 1886. Before that time only a return of the quantity of fish conveyed inland by rail had been issued ; and although the Scottish Fishery Board had for many years obtained some statistics of the fish caught and landed in Scotland, none had been recorded in England, Wales, or Ireland. The Fishery Statistics are now annually issued in a series continuous with the old return of rail-borne fish, which is still included among the tables. The return now gives the total quantity and value of the different kinds of fish landed, the average price, the quantities for the different coasts of England and Wales, the quantities for the different months, and the totals for each port or district.

Within the last few years an agitation has developed among those engaged in the fishing industry on the east coast of England, concerning the capture of immature or undersized flat-fish, and the decrease in the supply of the more valuable kinds of these fish, namely, soles, turbot, brill, plaice, and lemon soles. The conclusion of the Commission of 1883–5 on this subject was as follows :

After carefully considering the whole evidence on the question of the decrease of fish, we are of opinion that—

As regards territorial waters:

(1) On many fishing-grounds, from the Moray Firth to Grimsby, there has been a falling off in the takes of flat-fish, both as regards quantity and quality.

(2) There has also been a decrease in the takes of haddock in certain places, chiefly in bays and estuaries.

As regards off-shore waters:

(3) No decrease, except in the case of soles, has been proved in the total takes of the North Sea.

Now let us turn to the statistics that have since been collected. The return for the year 1892 is not yet issued,* so that we have only six years to compare altogether; and this is a very short period to draw conclusions from, even if the statistics furnished all the particulars that were required to show the increase or decrease of the supply. The table below shows the total quantities in cwts. of the more valuable flat-fish landed on the coasts of England and Wales, and includes certain other items from the official tables. It will be seen

England and Wales—all Coasts.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	15,403	16,571	17,740
Turbot . . .	59,850	63,166	55,041	53,576	51,879	56,875	62,630
Soles . . .	98,078	85,316	72,522	74,143	72,129	82,688	72,821
Other prime fish .	370,014	115,850	113,415	35,982	46,771	38,754	50,655
Total prime fish .	527,942	264,332	240,978	163,701	186,182	194,888	203,846
Plaice . . .	—	—	698,142	594,307	622,577	711,322	696,227
All fish except shellfish . .	6,412,433	6,029,481	6,348,072	6,464,564	6,100,630	5,966,076	6,485,699
Total, excluding salmon . .	6,397,367	6,012,371	6,340,774	6,460,064	6,095,512	—	—
Total value, excluding shellfish £	3,688,079	3,778,958	3,948,013	3,862,389	4,368,552	4,491,018	4,628,705
Drift-net fish . .	2,740,579	2,080,435	2,299,383	1,428,118	1,291,661	1,789,561	2,059,062
Bottom fish . .	3,671,854	3,949,046	4,048,689	5,036,446	4,808,969	4,176,515	4,426,637

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* See postscript.

from this table that the total quantity of all fish exclusive of shellfish shows fluctuations, but not steady increase or decrease. It is true that the quantity for 1891 is the least of the six totals, but the difference is not great, and the fluctuations in the other five years show that no definite importance can be attached to it. The inclusion or exclusion of the item salmon makes no appreciable difference in the result, but it is puzzling to find that there is no separate item for salmon in the year 1891, and no explanation of the omission is to be found in the memorandum which precedes the tables.

It will be seen that the figures under the item "Prime fish not separately distinguished" are so irregular that it is quite impossible to understand them. The cause of the irregularity lies evidently in changes in the method of classifying and estimating the fish followed by the returning officers. We cannot believe that certain kinds of fish constantly included under this item have fallen off to such an extent. We must conclude that this item has been enormously diminished by the abstraction from it of increasingly greater quantities which have been included under the special items. For practical purposes, then, this item is useless. If we look at the item soles, we find that the quantity for 1891 was greater than for any year except 1886 and 1887, so that on the whole there has been no very great decrease. Exactly the same is true of turbot. Assuming the figures to be reliable, however, there is a decrease in these items since 1886. Plaice has only been separately distinguished since 1888, and the annual total shows an increase, the figures for 1891 being the maximum. Brill has only been separately distinguished for two years, and nothing can therefore be said about it. It is a remarkable fact that there is no mention of lemon soles as a separate item, although these fish are sold separately at most of the fishing ports, and form an important proportion of the total catch of the deep sea trawlers. Moreover the fishing industry includes lemon soles among the flat fishes for which protection is demanded. We may note that the total value of the fish landed has increased enormously in the six years, the value in 1891 being three quarters of a million pounds greater than in 1886.

As it is trawl-fishing which is chiefly concerned in the present agitation I have added together the quantities under the items mackerel, herrings, pilchards, and sprats, and given the result separately as the total of drift-net fish, and given the remainder of the whole quantity as the total of bottom fish. The latter item includes certain other fish which are not bottom fish, such as salmon and mullet; but the quantities of these are relatively small, so that the figures I have obtained as bottom fish probably represent fairly well the total catch of deep sea trawlers. It will be seen, then, that there has been a much greater falling off in drift-net fish than in bottom fish, considering all the coasts of England and Wales together. The item bottom fish increased greatly till 1889, but has fallen off in the following two years.

If we examine the various coasts separately, we find that the results for the east coast are closely similar to those for all coasts together. In the total quantity of fish landed, there was practically no decrease until 1889, but a decrease in 1890 and 1891. The total quantity of soles was greater in 1891 than in any other year except 1886 and 1887. The quantity of turbot was less than in 1886, 1887, and 1888, but greater than in 1889 or 1890. The quantity of plaice is at a maximum in the last year of the series.

England and Wales—East Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	11,746	13,531	14,590
Turbot . . .	55,524	57,561	48,760	44,272	40,763	47,594	52,780
Soles . . .	82,677	67,874	52,151	47,747	46,187	61,287	52,934
Other prime fish .	364,557	109,424	105,057	25,848	34,391	30,197	40,265
Total prime fish .	502,758	234,859	205,968	117,867	133,087	152,609	160,569
Plaice . . .	—	—	628,658	518,688	548,784	647,915	620,951
Total except shellfish	5,321,656	5,157,678	5,260,350	5,223,635	4,719,237	4,670,646	5,105,814
Drift-net fish . .	1,965,657	1,628,102	1,664,854	1,790,350	1,307,410	1,100,410	1,388,937
Bottom fish . .	3,355,999	3,529,576	3,595,496	3,433,285	3,411,827	3,570,236	3,716,877

On the south coast the total quantity of all fish except shellfish has greatly decreased, but the decrease has been in drift-net fish, not in flat fishes or trawled fish generally. The quantities of turbot and soles landed has greatly and steadily increased, although there was a slight falling off in 1891. Plaice, on the other hand, has decreased.

The west coast shows an enormous and steady increase in the total quantity of fish landed, the amount in 1891 being more than three times that of 1886. The increase has been largely in mackerel. With regard to flat-fish, turbot and soles have very greatly increased, with a slight falling off in 1891; and plaice, as on the south coast, has decreased.

South Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	2,822	2,070	2,070
Turbot . . .	3,211	3,582	4,408	5,838	6,733	5,392	6,231
Soles . . .	9,555	9,314	11,256	12,709	12,159	10,808	9,126
Other prime fish .	5,457	6,426	8,358	10,134	12,380	8,557	10,390
Total prime fish .	18,223	19,322	24,022	28,681	34,094	26,827	27,817
Plaice . . .	—	—	55,788	52,360	46,588	44,378	47,207
Total except shellfish	871,041	642,914	605,808	652,471	586,501	595,705	599,749
Drift-net fish . .	638,479	349,464	307,188	312,834	227,808	319,353	319,275
Bottom fish . .	232,562	293,450	298,620	339,637	358,693	276,352	280,474

When we separate the quantities of drift-net fish, as was done for all the coasts together, and describe the remainder as bottom fish,

West Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	835	970	1,080
Turbot . . .	1,115	2,023	1,873	3,466	4,383	3,889	3,619
Soles . . .	5,846	8,128	9,115	13,687	13,783	10,593	10,761
Other prime fish .	—	—	—	—	—	—	—
Total prime fish .	6,961	10,151	10,988	17,153	19,001	15,452	15,460
Plaice . . .	—	—	13,696	23,259	27,205	19,029	28,069
Total except shellfish	219,736	228,889	481,914	588,458	794,892	699,725	780,136
Drift-net fish . .	136,443	102,869	327,341	324,934	465,426	369,798	350,850
Bottom fish . .	83,293	126,020	184,573	263,524	329,466	329,927	429,286

we find that on the east coast the latter item has varied but little. It was greatest in 1888, and the next highest figure is that for 1891. On the other hand, the total of drift-net fish has decreased steadily since 1886. On the south coast the annual quantity of drift-net fish has been pretty steady for four years out of the six, but the total for 1891 is only half that for 1886. Bottom fish on the south coast increased greatly to a maximum in 1890, but fell back considerably in 1891. On the west coast both drift-net fish and bottom fish have enormously increased.

These results are chiefly, perhaps entirely due to the fact that in recent years a large number of east coast boats of the largest size, both trawlers and drifters, have annually spent a portion of the year in fishing on the more distant grounds on the south and west coasts of England and the south coast of Ireland. Sailing and steam trawlers have fished on the grounds to the south and west of the Wolf Rock between the Scilly Isles and Mount's Bay, off the north coast of Cornwall and in the British Channel. Every spring a large fleet of mackerel boats from Lowestoft make Plymouth their headquarters, and land their fish at that port. The effect of this recent movement in the fishing industry is plainly indicated by the figures in the official return of the total quantities of fish landed at the principal ports on the several coasts (Table below). Thus we see that the quantity landed at Grimsby has slightly decreased, at Lowestoft has varied but little, at Plymouth has steadily increased, and also at Brixham; at Tenby there has been a decrease, while Milford (including Neyland) has sprung from nothing to be as important a port in relation to landing fish as Lowestoft.

	1886.	1887.	1888.	1889.	1890.	1891.	1892.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Grimsby . .	1,363,595	1,342,240	1,401,270	1,350,430	1,297,560	1,258,840	1,377,640
Lowestoft . .	502,097	476,947	476,718	599,946	417,373	572,777	627,578
Plymouth . .	141,712	150,157	132,087	164,864	163,884	179,353	135,241
Brixham . .	48,280	59,863	62,891	81,317	95,612	61,460	59,103
Tenby . .	10,232	9,451	10,363	8,791	6,910	6,349	4,201
Milford and Neyland . . .	—	5,690	157,419	270,576	484,006	403,657	370,687

Now it is clear that an increase in the quantity of fish landed may very well be produced by an increase in the size and number of boats, and the fact that they visit new and distant grounds, at the same time that the productiveness of grounds formerly used is declining. The most rigid and reliable test of the productiveness of a given fishing-ground would be to compare the average quantity of fish caught in a given time by the same or a similar boat in successive years. The Fisheries Department of the Board of Trade has not yet attempted this. Indeed, it has not attempted anything in relation to this subject beyond the collection of the quantities of fish landed, distinguishing certain kinds of fish, different coasts, and different ports. There is absolutely nothing in the statistical tables and memorandum concerning the number of men and boats or the size and character of the boats employed in the fisheries, if we except a brief reference in the memorandum of the first return, that for 1886. In this memorandum the number of boats and men was quoted from the Annual Statement of Navigation for 1885, and the *value* of fish landed was calculated per boat and per fisherman. In order, then, to ascertain the number or particulars of boats and men employed in our fisheries in successive years we have to examine the Annual Statements of Navigation and Shipping. We find there the number of boats registered under the Sea Fisheries Act of 1868, arranged in three classes. The Navigation Statement has, since 1876, been prepared by the Commercial Department of the Board of Trade, and, since it is signed only by the Assistant Secretary of that department, it appears that the Fisheries Department has nothing to do with it. So that, notwithstanding the organisation of the Fisheries Depart-

Boats registered in England and Wales under Sea Fisheries Act, 1868.

	Total number of 1st class boats.	Total tonnage 1st class.	Total number all classes.	Total tonnage all classes.	Total number of regular fishermen.	Number of men required for boats.
1871	2,582	90,224	15,615	131,092	—	—
1872	2,778	100,332	15,331	140,535	—	—
1873	2,851	104,642	15,049	145,134	—	45,398
1874	2,934	110,500	15,029	150,268	25,576	46,525
1875	2,979	111,784	14,830	151,041	26,245	44,142
1876	3,142	121,445	14,809	160,332	28,238	43,399
1877	3,425	137,768	13,294	174,174	30,408	35,883
1878	3,637	149,343	10,786	182,415	30,480	31,277
1879	3,767	155,941	10,639	189,006	29,408	31,375
1880	3,840	161,450	10,524	194,532	28,835	28,085
1881	3,870	162,417	10,357	195,348	29,141	27,792
1882	3,931	170,367	10,373	203,355	30,802	27,512
1883	3,743	161,830	8,880	190,517	31,810	30,152
1884	3,840	169,161	8,622	197,300	32,631	28,020
1885	4,040	183,694	8,826	212,176	33,422	28,520
1886	4,011	189,375	8,447	216,349	34,080	32,086
1887	4,014	190,464	8,390	217,346	34,526	30,914
1888	3,982	189,292	8,417	215,725	33,509	32,823
1889	3,928	187,724	8,271	213,542	33,474	33,429
1890	3,879	183,910	8,050	208,389	32,503	30,330
1891	3,873	183,421	8,063	207,515	33,044	28,885
1892						

ment in 1886 to take over all fisheries business, the Act of 1868 is not administered by that department. The first class of fishing-boats includes those of fifteen tons and upwards; the second class, those less than fifteen tons not navigated by oars only; the third class, boats navigated by oars only. The table on the preceding page shows the boats on the register in successive years from 1871 to 1891. I have also extracted the number of men and boys constantly employed in fishing, compiled from estimates made by the collectors of customs, omitting the figures of those occasionally employed, and I have given the number of men and boys required to work the boats whose certificates were produced and endorsed. But both these sets of figures are only approximations, for the production of certificates every year is not everywhere rigidly enforced. The important points brought out by these figures concerning boats and men are the following.

The total number of first-class boats increased steadily from 1871 to 1885—namely, from 2582 in 1871 to 4040 in 1885. Since the latter year the number has slightly decreased down to 3873 in 1891. The total number of boats of all classes steadily decreased from 15,615 in 1871 to 8063 in 1891. The total tonnage of all classes included increased steadily from 131,000 in 1871 to 217,000 in 1887, since when it has slightly decreased to 207,000 in 1891. The total number of regular fishermen increased from about 25,000 in 1874 to 34,526 in 1887, since when it has decreased to 33,044.

Now, logically to pursue the inquiry into the increase or decrease of the fish supply, in particular of the supply of various kinds of trawled fish, and of all kinds together, it would be necessary to be able to compare the catch obtained by equal catching power in a series of years. This has recently been attempted by the Fishery Board for Scotland, which, having adequate powers, has been able for the past three years to collect statistics of the tonnage and value of trawlers fishing on the Scottish coast, and the quantities of fish landed by these trawlers, apart from the fish landed by other boats. This has not been done for England and Wales, and could not be done by the present defective organisation of fishery authorities in this part of the kingdom. The Scottish Board has an efficient scientific department managed by competent scientific men, who have devoted their trained powers and scientific methods to the problems of sea fisheries. They have also the whole coast divided into districts, each provided with a competent fishery officer who has complete knowledge and experience of the fisheries, but no pecuniary interest in them. The scientific authority can thus without difficulty obtain any information it requires.

The statistics thus obtained by the Scottish Board are discussed in detail by Dr. Fulton in the Board's tenth report, 1892. He finds that the tonnage of Scottish trawl-vessels has increased from 2004 in 1883 to 6484 in 1891. The separate particulars of steam trawlers, which make up the greater part of this tonnage, have only been obtained since 1889. The fish landed by trawlers in Scotland has been separately recorded since 1888, and Dr. Fulton states that the total quantity has increased from 250,000 cwt. in 1888 to 323,046 cwt. in 1891. But, on the other hand, the quantity of fish per ton of the vessels' tonnage has decreased from 92·9 cwt. to 49·8 cwt. He is able further to give the quantity of round-fish and flat-fish per ton of the vessels' tonnage separately, and also the proportional quantity of several single kinds of fish. He finds in all except in skates a great falling off.

However, it must be pointed out that, in the first place, it is not safe to rely upon conclusions drawn from a series of statistics extending over so short a period; and in the second place, that the Scottish trawlers have been greatly handicapped by the closure of such extensive areas as the Firth of Forth and other territorial waters where they formerly fished.

In the following table I have indicated all that can be done in the way of comparing the statistics of fish caught, and boats employed, available for England and Wales. It will be seen that the hundredweights total fish per ton of total tonnage of fishing-boats shows slight fluctuations, but no continuous increase or decrease. There is no possibility of distinguishing trawlers and drifters among the boats registered. I have, therefore, compared the quantities of soles and turbot per first-class boat, and per ton of the aggregate tonnage of first-class boats; that is to say, I have supposed the number and tonnage of trawlers to be always in the same proportion to the aggregate numbers and tonnage of first-class boats—a supposition which may be correct or not. The results, however, are not without interest. Thus the quantities of soles per first-class boat for the several years follow almost exactly the same order as the total quan-

	Cwt. soles per 1st-class boat.	Cwt. soles per ton 1st class.	Cwt. total fish per ton total tonnage.	Cwt. turbot per 1st-class boat.	Cwt. turbot per ton 1st class.	Total value per ton total tonnage.
1886	24·45	·51	29·63	14·92	·31	£17
1887	21·25	·44	27·74	15·73	·33	17
1888	18·21	·38	29·42	13·82	·29	18
1889	18·87	·34	30·27	13·63	·28	18
1890	18·59	·33	29·22	13·37	·28	20
1891	21·34	·45	28·75	14·68	·31	21
1892	—	—	—	—	—	—

tities of soles landed. But whereas the absolute quantities in 1890 and 1891 are less than in the years 1888 and 1887 respectively, the quantities per first-class boat in the former years are greater. When we examine the quantities per ton of first-class boats we find a still greater difference from the absolute quantities, the proportion for 1891 being higher than for any other year except 1886. Taking next the turbot, we find that the quantities per boat follow the same order as the absolute quantities, and so also do the quantities per ton of first-class boats. The last column of the table shows that the annual earnings per ton of total tonnage have steadily increased in the six years, so that although the public are poorer on account of the increase in the price of fish, it would seem that the men and boats actually earn more money every year. But this result, again, requires qualification, for there has been especially on the north-east coast of England a great increase in the number of steam trawlers, and everywhere within the last six or seven years steam machinery has been more and more generally used on sailing vessels as well as steamers for hauling up the trawl. The steam trawler can make more hauls than the sailing vessel, and yet her tonnage is registered as less than that of a sailing vessel of the same size. For instance, a steam-vessel of fifteen tons gross is registered in the first class, but the tonnage entered for her is the net registered tonnage, which is less than fifteen tons. Taking these difficulties into consideration, it is not worth while to calculate the quantities of fish per boat or per ton for the several coasts separately.

Summary.—To summarise these results, then, the analysis shows that there has been no continuous decrease in the total quantity of fish caught, nor in the quantity of total fish per ton of the total tonnage of all kinds of boats. When we deduct the quantities of mackerel, herrings, pilchards, and sprats, we find there has been a considerable decrease in the total quantity of drift-net fish landed, and a corresponding increase in the total quantity of other kinds of fish. The total number of fishing-boats has steadily decreased since 1871, but the total tonnage reached a maximum in 1887. There has been a decrease, but not a continuous decrease in the quantity of soles and turbot landed, but an increase in the total quantity of plaice. The decrease in the quantities of soles and turbot has been confined to the east coast, and there no decrease in plaice has occurred. On the south and west coasts the quantities of soles and turbot landed have largely increased, and plaice also on the west coast; on the south coast plaice have somewhat decreased.

Postscript.—After this paper was finished the statistical tables and memorandum for 1892 were published. I have therefore inserted the figures for this year in the tables, but time is not available to recast the paper and incorporate the returns for this year in it. It will be seen that my general arguments are confirmed by last year's figures. Soles for all coasts have fallen again, but turbot have nearly reached the maximum figures of 1887. The total fish excluding shellfish is greater than in any other year since statistics were collected, and so is the value. Drift-net fish have increased again, and the total of bottom fish is higher that in 1891. Similar remarks apply to the east coast considered separately.

A new feature in this return is Part III—A Statement of the Boats and Men for the years 1888 to 1891 inclusive. I have given these years among the whole series of years for which I have extracted these particulars from the Annual Statement of Navigation, and what I have said on this head requires no modification.

My hope and expectation that the extraordinary treatment of lemon soles in the tables would be remedied in this return are utterly disappointed. No change whatever is made. Lemon soles are placed in the Scotch tables as prime fish equivalent to soles in the English tables, while they are not mentioned at all in the latter, and English soles and Scotch lemon soles are added together to produce the total of soles for the United Kingdom. The official statistics of fish remind one of the French phrase, "Plus ça change, plus c'est la même chose."

II. SCIENTIFIC INQUIRIES.

1. At Plymouth.

Since last Christmas, in accordance with the Council's special instructions, I have been making systematic investigations into the question of the capture and destruction of immature or undersized fish at Plymouth. The following is my report on these investigations as far as they have yet gone. By immature fish in the tables I mean females in which there is no trace of yolk in the young eggs in the ovary when examined under the microscope. Immature males have been distinguished by the extremely undeveloped state of the testes. All the males registered as mature either contained ripe spermatozoa or were obviously spent.

Lemon Soles or Merry Soles.

Between January 1st and March 11th I examined 220 specimens of this species (*Pleuronectes microcephalus*) procured from the fish quay as landed for sale. The examination was carried out in the

Laboratory with the utmost minuteness and attention, and the results are shown in the following table.

Lemon (Merry) Soles, December 31st, 1892, to March 11th, 1893.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	0	0	0	0	0
7 ,,	10	7	0	3	0
8 ,,	14	10	0	4	0
9 ,,	26	16	0	10	0
10 ,,	50	34	0	16	0
11 ,,	54	31	0	23	0
12 ,,	28	17	0	11	0
13 ,,	26	12	0	14	0
14 ,,	9	2	0	7	0
15 ,,	1	1	0	0	0
16 ,,	2	0	0	2	0
17 ,,	0	0	0	0	0
18 ,,	0	0	0	0	0
	220	130	0	90	0

Under 11 inches—100.
Over 11 inches—120.

Not one specimen was immature. The period extended from just before the spawning period to the middle of that period, and every specimen was either ripe, or in such a condition that it would evidently have spawned this season if it had been left alive in the sea. All the males were actually ripe, yielding ripe milt when squeezed, or were nearly spent. The excess in the number of males over females is probably due to the fact that a disproportionate number of small fish were examined, and the males being smaller, a given number of small fish includes more males than females. It is probable enough that some of these fish were preparing to spawn for the first time in their lives, so that they were killed before they had actually been allowed to reproduce their kind; but it is not possible in such an examination of the fish as this with our present knowledge to ascertain whether a specimen is ripening for the first time or has spawned in previous seasons. But the evidence proves that in the period mentioned immature merry soles are not landed at Plymouth. At other times of the year immature specimens may be landed, but if so, I believe the proportion of such is small and unimportant. At the Conference convened by the National Sea Fisheries Protection Association in 1892, the limiting size adopted for lemon soles was 11 inches in total length. Of the specimens included in the above table 100 were under that size and 120 over—that is to say, 45 per cent. of the number were under 11 inches in length. This, however, may not represent accurately the average proportion among all the fish of this kind landed. I will give, therefore, the results of observations which I made during a three days' trip on board a trawler at the beginning of March. We were trawling off Dodman Point in Cornwall, a ground where merry soles are usually abundant. We took 264 of these fish altogether. None of these were immature, and none were returned to the sea as unsaleable; the smallest was 7 inches long, 179 of these were over 11 inches in length, 85 were under that length. That is to say, 32 per cent. of the merry soles caught were under the proposed limit. Merry soles form a very important part of the total catch of a trawler fishing out of Plymouth, and they fetch a very good price. There would be the strongest opposition on the part of Plymouth trawlers to a proposal that they should be compelled to throw away 32 per cent. of the merry soles they catch.

The smallest merry sole I have ever obtained at Plymouth was 6·4 inches long, and this was a perfectly ripe male. As far as my experience goes, smaller specimens than this are never caught either by deep sea trawlers or any other kind of fishing-boats.

The merry sole or lemon sole is not a large fish. The largest obtained by Dr. Fulton on the east coast of Scotland was 18 inches long. I have not yet seen any at Plymouth over 17 inches in length, and no males over 16 inches.

On the south coast merry soles, large or small, are not captured by any boats, or very exceptionally, other than the deep sea trawlers, and they are only found in abundance at a considerable distance from the coast. The inshore waters, which yield often plenty of plaice, supply very few merry soles. Neither the full-grown nor the young of this species are taken in any numbers in territorial waters on British coasts. The evidence available shows that the young lemon soles when they first go to the bottom, instead of seeking the shore as young plaice do, travel in the opposite direction, and pass the first period of their lives at depths greater than those where the adults abound. Dr. Fulton, in his systematic search on the coast of Scotland, obtained only four specimens as small as 2 inches, although he obtained 64 out of a total of 195 under 8 inches. On the west coast of Ireland, the Irish Survey of 1890–91, obtained three specimens 1¼ inches long at depths of fifty-two to sixty fathoms. Mr. Holt has, however, recently found that young lemon soles 2 to 4 inches in length are not rare in the estuary of the Humber in autumn. But these were not in large numbers, the greatest number caught in one haul of the shrimp trawl being sixteen. We may, therefore, practically confine our attention to the deep sea trawlers.

Mr. Holt has been investigating the question on the east coast for the North Sea since January, 1892. He says that the male lemon sole is sometimes mature at 6 inches, and that no specimen smaller than this could be procured. He says he has found immature females from 6 inches to 12 inches in length. But not all females are immature under 12 inches or under 11 inches. Many were mature at 10 inches, some at 9 inches, and one female even at 8 inches. Mr. Holt examined 424 specimens, the smallest he could procure, by far the greater number under 11 inches in length; and of these, 125 were immature—that is, 29 per cent. If we take only those under 11 inches examined by him, the numbers are these:—Total number examined, 263; immature, 101, or 38 per cent. Even this is not a very large proportion. I do not think it is large enough to justify any legislative interference with the capture of lemon soles. Mr. Holt states that young lemon soles are not taken on the eastern grounds.

It is certain, therefore, from the evidence reviewed that neither immature nor undersized lemon soles are captured by the deep sea trawls in excessive proportion on any particular grounds, and the question with regard to this particular fish is narrowed down to this:—Is it necessary or advisable to interfere in any way with the capture and sale of the smaller lemon soles, which the trawlers at present take on all ordinary off-shore fishing-grounds?

In the first place it must be noted that all the lemon soles taken are saleable and good for food. None are thrown overboard as useless, and all find a ready market. If a limiting size is enforced either the prohibited fish must be thrown overboard, or the fishermen must find a method by which they can avoid catching them. If they are forced to throw the small fish overboard, it is certain that they will not all be returned to the sea alive. It is doubtful if any or more than a very small proportion would survive if thrown overboard. According to my experience at Plymouth, it is seldom that the fish are sorted out and picked up as soon as they are emptied from the trawl on to the deck. In rough weather, and when the trawl contains a large quantity of stuff, the fish have been subjected to a good deal of mechanical violence before they reach the deck. Then the trawl is frequently torn, and it is mended and shot away before the fish receive any attention. Again, hauls are frequently made at night, when it would be troublesome and difficult to distinguish the smaller fish. In a great many cases the fish would not be thrown overboard until they were dead or beyond hope of recovery.

An enlargement of the mesh of the net has often been suggested;

but this will be considered in reference to the protection of immature fish generally. It is enough to state here that no enlargement of the mesh sufficient to allow lemon soles of 7 or 8 inches in length has yet been proved to be practicable.

It has been shown by my own observations at Plymouth, and Mr. Holt's at Grimsby, that practically no lemon soles are taken which are less than 7 inches in length. Now this length bears the same proportion to 18 inches, the maximum length of the lemon sole, as 10$\frac{7}{8}$ inches does to 28 inches, the maximum length of the plaice. Therefore, since it is proposed to restrict the capture of plaice to those above 10 inches, the corresponding restriction with regard to lemon soles, as actually now enforced by natural conditions, is an established fact without the aid of law. To put this aspect of the matter in another light, if it is proposed to set up a limit of 11 inches for lemon soles, then the corresponding limit for plaice must be 17 inches, for 11 bears to 18 the same proportion as 17 to 28. I do not think the fishing industry would consent to a law which prohibited the landing or sale of plaice under 17 inches. The limiting sizes adopted by the conference of 1892 were for turbot and brill 12 inches, for lemon soles 11 inches, for plaice and soles 10 inches; and yet both the plaice and the sole grow to a larger adult and maximum size than the lemon sole.

My conclusion, then, is that no case has been made out for any interference with the capture, landing, or sale of lemon soles. Where it is found that a kind of fishing is practised which is diminishing or endangering the supply of a particular kind of fish without producing any great profit either to those engaged in it or to the community, then it is allowable to restrict or prohibit that kind of fishing. But the evidence at present available shows that any restriction of the fishing for lemon soles now carried on would be a hardship to the fishermen, a loss to the public, and of no certain benefit to the fishery.

It does not necessarily follow that if the supply of a certain kind of fish is diminishing, laws must be passed with the object of stopping the diminution. It may not be possible to improve the supply by special measures. When that is the case we must wait until the limit of diminution is reached; at a certain point the increase of the appliances for capture will also cease, because profits will be reduced to a minimum, and so an equilibrium will be established. But it is necessary to point out that in the case of lemon soles we have no sufficient evidence that the supply is diminishing or has diminished; scarcely any evidence at all on the question. For England and Wales we have no statistics of any kind with regard to lemon soles; as far as this fish is concerned no statistics have yet been collected. Trawlers and fish traders at Plymouth unanimously maintain that in that neighbourhood the supply of merry soles has increased in recent years. They say that formerly, ten years ago, merry soles were not abundant enough to be sold separately; they were sold mixed with plaice as flat-fish. Now they are sold separately, and form an important item in the trade. The fishermen say that this is not due to an increase in the number of boats or an increase in the price of the fish, nor to the working of new grounds. They say that they get many more merry soles now on the same fishing-grounds than they did from five to ten years ago. What is the case in the North Sea I cannot say, but for the east coast of Scotland we have statistics. The gross quantity of lemon soles landed in Scotland is still increasing, while the total quantity of turbot, and of flounders, plaice, and brill together, appear to have reached a maximum about 1888 or 1889. Between 1888 and 1891 the quantity of lemon soles has increased from 12,667 hundredweight to 17,739 hundredweight. But, on the other hand, Dr. Fulton finds that the quantity of lemon soles caught by beam trawlers per ton of the vessels' tonnage decreased in the years 1889 to 1891. As I have mentioned before, no important conclusions can be drawn from statistics limited to three years. Thus it is shown that, on the one hand, there is no evidence at present of a statistical nature of a decrease in the supply of lemon soles, nor, on the other hand, any evidence from the natural history of the fish, or an examination of the fishery, that benefit could be obtained by imposing regulations or restrictions, or interfering in any way whatever.

Plaice.

The following table gives the results of examination of all the plaice examined in the period mentioned. It simply serves to show the relation of sexual maturity to size in this species at Plymouth.

The largest immature female was 14½ inches long, the smallest mature female 9 inches, so that from 9 inches to 14½ inches is the borderland within which some females are mature and others immature. The smallest mature male was also 9 inches long and the largest immature 12 inches.

Mr. Holt's results from observations on the east coast, as described in the preceding number of this Journal, are somewhat different. It is true he had examined a larger number of specimens. He once found a ripe male only 6 inches long, but this he rightly regards as quite exceptional. Apart from this, his smallest mature male was 9 inches long, and his largest immature 15 inches. Of females, his smallest mature was 13 inches long, and his largest immature 17 inches. These differences correspond closely with the difference in maximum size of plaice on the east and south-west coasts of Britain. Dr. Fulton states (8th Report of Scottish Fishery Board) that the largest plaice found on the east coast of Scotland was 28 inches long. Mr. Holt tells me that he has never seen a North Sea plaice more than 27 inches long, although possibly one of 28 inches may occur occasionally. The maximum observed by me at Plymouth is 25 inches. There can be no doubt that the average adult size corresponds to the maximum size. There is still some little uncertainty in distinguishing an immature fish from one that has recovered from spawning. Mr. Holt's discussion of this question in the preceding number of the Journal does not entirely exclude the possibility that some months after spawning the roe of a spawned fish may be similar to that of one which has never spawned at all. But among fish examined during the spawning season, as most of Mr. Holt's and all of mine were, there can be hardly any uncertainty from this cause. Therefore, if we take what Mr. Holt calls the biological limit, the length which will certainly exclude all immature fish, which is 18 inches for the North Sea, it is 15 inches for the south-west coast. So much for the biological question apart from the practical.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	1	0	0	0	1
7 „	26	0	10	0	16
8 „	13	0	4	0	9
9 „	4	2	0	1	1
10 „	8	4	1	0	3
11 „	6	3	1	1	1
12 „	8	4	1	1	2
13 „	12	5	0	5	2
14 „	10	4	0	3	3
15 „	3	1	0	2	0
16 „	9	1	0	8	0
17 „	1	0	0	1	0
18 „	2	0	0	2	0
19 „	1	1	0	0	0
20 „	1	0	0	1	0
21 „	2	0	0	2	0
22 „	0	0	0	0	0
23 „	0	0	0	0	0
24 „	1	0	0	1	0
25 „	1	0	0	1	0
	109	25	17	29	38

The fish included in the first table were partly samples of those landed by trawlers, deep sea trawlers, and partly samples of those captured by small ground seines in the estuaries near Plymouth, chiefly in the estuary of the Tamar, called the Hamoaze. It is very instructive to exhibit the details concerning these two classes of fish separately, as I have done in the tables on this and the next page.

Plaice: January 1st to March 11th, 1893.

From Trawlers.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
7 inches	1	0	0	0	1
8 ,,	2	0	2	0	0
9 ,,	3	2	0	1	0
10 ,,	8	4	2	0	2
11 ,,	5	3	1	1	0
12 ,,	8	4	1	1	2
13 ,,	12	5	0	4	3
14 ,,	10	4	0	3	3
15 ,,	3	1	0	2	0
16 ,,	9	1	0	8	0
17 ,,	1	0	0	1	0
18 ,,	2	0	0	2	0
19 ,,	1	1	0	0	0
20 ,,	1	0	0	1	0
21 ,,	2	0	0	2	0
22 ,,	0	0	0	0	0
23 ,,	0	0	0	0	0
24 ,,	1	0	0	1	0
25 ,,	1	0	0	1	0
	70	25	6	28	11

Total number examined	70.
Immature	17 = 24 per cent.
Under 10 inches	6 = 8 ,,
Under 17 inches	61 = 87 ,,
Under 14 inches	39 = 55 ,,

Thus, of the plaice landed by trawlers, 24 per cent. were immature, of those landed by the seines, 100 per cent. The trawled fish contained more than the average number of small fish, because on several occasions small fish were selected for examination, and consequently the percentage of immature among trawled fish taken all together is less than 24. The other percentages given are interesting in relation to the various proposals for restriction which have been made.

It is a well-established fact, the evidence for which has been published in full by Dr. Fulton, Mr. Holt, and myself, that the young of the plaice when they first take to living on the sea bottom seek the shore, and pass the first part of their lives in bays and estuaries and in shallow water. In consequence of this fact we see that at Plymouth the principal destruction of small fish is caused by inshore fishing, such as the seines in the Hamoaze. Inshore trawling and large ground seines used at Teignmouth and Dawlish doubtless are equally destructive. It must be remembered that this destruction is not remunerative to the men who practise it. Plaice of 7 or 8 inches long fetch a low price, and are poor food even as compared with merry soles of the same size. There can be no doubt that trawlers working in shallow water, in the bays and close to shore, take a large proportion of small and immature plaice. On the south-west coast there are no flats which extend far out from the shore into extra-territorial waters, and I know of no ground where small plaice are taken in excessive proportion to large except in territorial waters. It has been proposed by the Devon Fisheries Committee to exclude beam trawling in great part of their territorial waters altogether. This would of course put an end to the destruction of small plaice at present effected by those boats in those waters. But it would not affect the destruction, which is due to other kinds of fishing, in particular to ground seining.

Plaice: January 1st to March 11th, 1893.

From Seines in Hamoaze, &c.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	1	0	0	0	1
7 ,,	25	0	9	0	16
8 ,,	11	0	2	0	9
9 ,,	1	0	0	0	1
10 ,,	0	0	0	0	0
11 ,,	1	0	0	0	1
12 ,,	0	0	0	0	0
	39	0	11	0	28

Total number examined	39.
Smallest	6¼ inches.
Largest	11¼ ,,
Immature males	11.
,, females	28.

The measures which might be carried out for the protection of small plaice may be of the following kinds.

(1) Prohibition of landing, possession, or sale of fish under a certain limit of size.

(2) Prohibition of fishing on certain grounds.
(3) Prohibition of capture in certain seasons.
(4) Mesh regulations.

The proposal to establish a size limit offers many difficulties. If the limit of 10 inches proposed by the National Sea Fisheries Protection Association were applied rigorously to all coasts of the kingdom, it would not bear very hardly on deep sea trawlers in the south-west. It would mean throwing overboard about 8 per cent. of the plaice caught, and as these are the smallest fish, it would not be a very great loss of earnings. Still it would be some loss, and would be strongly opposed by the fishermen. Then, again, the fish thrown overboard would not all be alive. Trawling in winter-time in strong winds is such rough work, and so much attention has to be given to mending and shooting the trawl and navigating the vessel, that the fish often cannot be picked out from the mass of stuff brought up by the trawl until it has been on deck some time. It is making a great demand on the crews of trawlers to expect them to carry a measure and measure their fish; and if they were forced to do it, they would think more of the importance of not throwing overboard any fish which they could legally keep than of returning the fish to the sea alive and in good condition. Fishermen, as a rule, do not understand the conditions necessary to the life of a fish. They almost always fail to bring fish alive when requested and paid to do so, because they do not handle them with enough care, or supply them with water properly.

On the other hand, Mr. Holt has proved that the Conference limit of 10 inches would not prevent fishing in the eastern grounds of the North Sea, the destruction of small plaice on which gave rise to the present agitation. No higher limit would be tolerated by the south coast trawlers. It must be remembered that it is not practicable to enforce the biological limit. On the south-west coast the limit is 15 inches, but a large proportion of the fish under this size are mature, and they are certainly marketable. To enforce this limit would deprive the trawlers of about 50 per cent. of the total number of their plaice, and probably dislocate the industry. Mr. Holt believes that a limit of 14 or 15 inches would be enough to prevent fishing on the eastern grounds of the North Sea, but he tells me that in winter a good many fish of this size are taken on other grounds, and suggests enforcing the restriction only in summer. It is of course true that the imposition of a size limit would prevent to a great extent the capture of small plaice by shrimping and seining in inshore waters. But there is a great deal of destruction carried on in shrimping and seining of plaice which are so small as to be unmarketable, and this would not be affected by the establishment of a legal size limit.

It seems to me that, apart from the question of the extra-territorial eastern grounds of the North Sea, if the capture of plaice could be prevented altogether in territorial waters in this country the fish would be protected to a most important extent, and the difficulty of interfering with the operations of deep sea trawlers would be avoided. At the same time beam trawling, except for shrimps, should not be allowed in territorial waters. There would be no greater difficulty in this than in preventing the capture of salmon by illegal nets, which has been done for years. Plaice taken by shrimp-net and seines can be returned to the water alive; those taken by deep sea trawls, speaking broadly, cannot. The wanton destruction of plaice by shrimpers and seiners can be easily punished by the local committees.

This proposal could not be carried out on the west coast of Ireland, where nearly all the available trawling-ground is inside the territorial limit. But there is no need for protection on that coast at present.

I need not consider the question of the enlargement of the mesh, because on the south-west coast the deep sea trawlers refuse to consent to it, for the reason that with a larger mesh they would not catch thickbacks (*Solea variegata*), queens (*Pecten opercularis*), or squid (*Loligo*), which make part of the men's earnings.

In order to prevent destruction on the eastern grounds of the North Sea it would be necessary, without a size limit, to close the grounds wholly or partially by means of an international convention.

It must be remembered that, as I have shown in the first portion of this paper, we have as yet no statistical evidence of a diminution in the supply of plaice, except a decrease in the total quantity landed on the *south coast*. Even Dr. Fulton's figures do not include separate figures for plaice.

Soles.

The soles of which the particulars are contained in the following table (p. 75) were all taken by trawlers and purchased on the landing quay. All of them were selected on account of their small size. The number is small, but the results are not likely to be greatly altered by examination of a larger number. There are no immature males among them. The smallest mature female is 12 inches long, the largest immature is 13 inches. Mr. Holt found in the North Sea no immature females above 12 inches, while his smallest mature female was only 10 inches long. Perhaps the soles on the south-west coast are a little larger in average adult size than in the North Sea. On the other hand, Mr. Holt found some males immature at 11 inches, and I have seen no immature males; but since the testes are so small it is difficult to be certain that a male is immature. The difference is in any case slight: according to Mr. Holt the "biological limit" of immaturity is 12 inches, according to my result 13 inches; but to exclude all immature fish it would have to be 13 and 14 inches respectively.

Soles: January 1st to March 11th, 1893.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	0	0	0	0	0
7 "	0	0	0	0	0
8 "	0	0	0	0	0
9 "	5	5	0	0	0
10 "	5	3	0	0	2
11 "	15	12	0	0	3
12 "	21	12	0	5	4
13 "	3	0	0	1	2
14 "	8	0	0	8	0
15 "	3	1	0	2	0
16 "	1	0	0	1	0
17 "	0.	0	0	0	0
	61	33	0	17	11

Total number examined . . .	61.
Immature	11=18 per cent.
Mature males	33=54 "
Under 10 inches	5= 8 "

It is important to notice that only eleven of these fish were immature, 18 per cent.; while among the sixty-one selected as the smallest obtainable, 54 per cent., more than half, were mature males. This shows how comparatively slight is the destruction of immature soles by deep sea trawlers on the south-west coasts. The smallest sole obtained was 9 inches long, but smaller specimens down to 8 inches have been seen on other occasions. Soles less than 8 inches long are not destroyed by deep sea trawlers landing fish at Plymouth. If the Conference limit of 10 inches were enforced it would mean throwing overboard much less than 8 per cent. in number of the soles taken.

It seems, then, more important to ascertain whether soles less than 9 inches long are destroyed, and if so how and where. A few are taken at Plymouth by the shrimp trawlers, but I have no statistics, and the number is not very great. I have heard that larger numbers are taken by the ground seines on the coast of Devon, but have not yet made personal investigation of this mode of fishing.

Curiously enough on the eastern grounds, which are so often referred to, small or immature soles are not taken in any important numbers, according to the observations of Mr. Holt. The destruction of soles too small for the market by inshore fishing in the Humber has been shown to be insignificant by Mr. Holt in the preceding number of this Journal, as they are returned to the sea alive. A considerable number, however, from 6 to 10 inches long are taken and sent to market by shrimp trawlers in the Humber. On the Lancashire coast Mr. Dawson finds similar facts with regard to soles. Large numbers of soles are taken in the district much under the size which should be taken, but few under 4 inches have been observed. In trials with the shrimp trawl Mr. Dawson constantly took small soles and plaice in such proportions as 4 to 900, 136 to 520, 8 to 720, and so on. The whiting were even more numerous than the plaice. On the west coast of Ireland Mr. Holt found only three soles under 10 inches out of a total of 529. The history of the early stages of the sole is by no means cleared up. The probable conclusion is that the young are not principally aggregated at particular depths or in particular regions, and few have been taken in deep water because small-meshed trawls have been little worked there. It is desirable, however, to protect the young which do occur in shallow water, and I think the best way would be not to allow them to be taken in territorial waters. As in the case of the plaice, it would be possible to compel the men to return all soles caught by inshore fishing alive to the water. It has been urged that it would not be practically easy to discriminate between fish caught in territorial waters and others. But it would be sufficient to inflict penalties for taking certain fish in territorial waters, without interfering with market, landing, or sale. In places where the fish were exceedingly abundant all kinds of fishing could be prohibited.

Turbot.

Hitherto I have only examined seven turbot, and these were the smallest I could obtain; none were under 12 inches, and all were landed by deep sea trawlers. Three were mature males, the smallest 13 inches long; there were no immature males. Three were immature females, the largest 17 inches long. The smallest mature female was 19 inches long. These results, so far as they go, indicate that there is no difference between the south-west coast and the North Sea with regard to this fish. Mr. Holt says the prohibition of turbot under 12 inches would not prevent the fishing in the eastern grounds in the North Sea, where a large number of immature turbot are taken and brought to market. There is no great destruction of turbot under 12 inches, saleable or unsaleable, anywhere ; but some are taken in inshore waters, &c., and it would be advisable to compel the men to return these to the sea alive. What has been said of the distribution of soles and measures for their protection applies also to turbot.

Brill.

I have examined eight brill, none under 12 inches, and all from deep sea trawlers, the smallest I could procure. There were no immature males and no immature females. The smallest mature female was 16 inches long. Immature brill are not taken, according to Mr. Holt, on the eastern grounds in the North Sea.

North Sea Investigations.

(*Continued.*)

By

Ernest W. L. Holt,
Naturalist on Staff in Charge of Investigations.

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INTRODUCTORY.

I HAVE again so many acknowledgments to make for help received that it would be invidious to select names, whilst to enumerate all would unduly trespass on the space allotted to me.

The work, as before, has been carried on at the Marine Fisheries Society's Laboratory at Cleethorpes.

I. ON THE RELATION OF SIZE TO SEXUAL MATURITY IN ROUND FISH.

Since the flat fishes appeared to be of more immediate importance, and time did not suffice for the thorough examination of both forms, I have deferred to deal with the round fishes until the present spawning season. Up to the time of writing only cod and haddock have been spawning, and neither species has ceased to do so. My records are therefore incomplete, even for these two forms, and especially for the last named, owing to the difficulty which has been experienced in procuring specimens from which the viscera have not been removed. Sufficient information, however, has been gained to justify the proposition of provisional size-limits, which will be useful in considering the statistics given below (p. 81) as to the destruction of undersized fish. For this purpose the observations of Dr. Fulton, who has now (Rep. S. F. B., 1892) enhanced the value of his former records by adding particulars as to sex, are of great assistance, since the conditions of the area from which his information was derived are, in great measure, identical with those of the parts of the North Sea with which I am here dealing.

The standards of maturity which I have proposed below are founded on the same basis as those put forward in the case of flat-fish. It seems preferable to deal with the methods of distinguishing the different conditions when the inquiry is more complete, but, of course, it may be taken that, *exceptis excipiendis*, what is true of one group of Teleosteans applies, in great measure, to others.

Cod (*Gadus morrhua*).

Provisional size-limit, 25 inches.

Examined during the spawning season.

Length.	MALES.				FEMALES.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 12 inches	1	0	0	1	1	0	0	1
,, 14 ,,	2	0	0	2	2	0	0	2
,, 16 ,,	1	0	0	1	1	0	0	1
,, 18 ,,	5	0	0	5	5	0	0	5
,, 20 ,,	9	0	0	9	8	0	0	8
,, 22 ,,	16	1	0	15	17	0	1*	16
,, 24 ,,	18	1	1	16	14	0	0	14
,, 26 ,,	30	8	1	21	22	3†	2	17
,, 28 ,,	43	10	9	24	37	0	15	22
,, 30 ,,	32	6	16	10	31	2	9	20
,, 32 ,,	27	12	11	4	29	2	22	5
,, 34 ,,	15	5	9	1	17	3	13	1‡
,, 36 ,,	2	0	2	0	2	0	2	0

Some larger and smaller fish examined were all mature and immature respectively. On account of the large size of this fish, I have used divisions of two inches instead of one inch as in smaller forms.

From consideration of the fish obtained during the survey on the west coast of Ireland, I expressed the opinion that the limit for the female should be about 26 or 27 inches. The above table seems to show that such a limit would not be too high for the North Sea; all the fish, however, were caught on the hook, and gravid females, though in this respect the species before us is less particular than some others, are known not to take a bait very readily. Moreover a good part of them are inshore fish, and on this coast the cod appears to spawn chiefly off shore. Hence it may be that the percentage of immature indicated by the table is somewhat too high to be applicable to the whole species. My inquiries are not yet complete, and I have therefore chosen a provisional limit which is very unlikely to have to be lowered.

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* Three parts ripe: exact length 22¾ inches.

† Smallest ripe fish: 26½ inches.

‡ Largest immature fish: 35 inches.

It appears from Fulton's observations (Rep. S. F. B., 1892, Tab. v, p. 239*a*) that on the east coast of Scotland the female may be nearly mature at 21 inches, and this, no doubt, occurs in exceptional cases in other parts of the North Sea. My own results show very little difference between males and females in the size at which maturity is reached, which is the less remarkable since the two sexes do not greatly differ in size; indeed, according to Fulton (op. cit., 1890, p. 247), the male is the larger fish of the two. The same authority, however, found the females to be the most numerous, and such is my own experience as regards specimens of all sizes. It is, therefore, rather singular that my table, which includes all the fish of the given sizes which I could procure here, shows an almost exact equality of number. The manner in which they were caught, which has a tendency, as I have mentioned, to be less efficacious in the case of gravid females, may partly explain the phenomenon so far as it is apparent in the case of the larger sizes in the table.

Haddock (*Gadus æglefinus*).

Provisional size-limit, 13 inches.

It appears from the limited number which I have as yet examined that the average size at which the female begins to spawn is about 13 or 14 inches. The largest immature and the smallest nearly mature examples of this sex measured 16 and 11 inches respectively, and the smallest fully mature specimen 15 inches. The male seems to mature at a somewhat smaller size, viz. about 11 inches; all males of less than 10 inches were immature, and in fish of less than 9 inches it was very difficult to find the testes at all. All of more than 12 inches were mature or nearly so. Fulton's table (loc. cit.) appears to indicate a very similar experience as to facts, and it is evident that the pre-eminence in size which this authority ascribes to the male is no bar to the latter attaining maturity at a smaller size than the female. If we assume that rate of growth is proportional to size, it would seem to follow that the duration of reproductive life must in this case be greatest in the male. That the same difference in attaining maturity is less apparent in the cod is probably explained by the greater advantage in size which Fulton's figures indicate for the male in that species: the male haddock being only very slightly larger than its mate, and having a longer reproductive life, the difference in the size at which the sexes spawn is more marked than in the cod, in which species the male, also fertile for the longer period, has a more noticeable advantage in size over the female.

II. On the Destruction of Immature Fish in the North Sea.

I propose to resume this subject at the point at which I left it in the last number of the Journal, and to arrange my remarks under the same headings.

Beam-trawling by Large Vessels.

That the destruction of small fish in this area is far greater in the summer than in the winter months is a fact which is probably sufficiently familiar to most readers of this Journal; the explanation being that it is only at the former time that young flat-fish congregate on certain grounds, alluded to in the last number of the Journal, in sufficient numbers to attract many boats to the grounds. Nevertheless a certain amount of small flat-fish appeared to be destroyed at all seasons of the year, whilst the destruction of young round-fish by trawlers is, as I shall endeavour to show, greatest in the winter months. The different species will be dealt with separately.

Plaice.—We have seen that the number of boxes containing only small fish landed here from the beginning of April to the end of August reached a total of 10,119. If we examine the figures for the different months we find the destruction at its maximum in June, each succeeding month showing a sensible diminution. I was given to understand, by those who should be well qualified to impart information on this point, that very little fishing would be done on the eastern grounds after the end of June; but, as the event proved, this was far from being the case. My informants, I have no doubt, spoke from their experience in former years, so that it would appear that the grounds in question remained productive, or were fished, to a later period than usual. If, as I suppose, the latter solution is in part correct, it does not appear that we have much to hope from the effect of public opinion on the fishing community in general, though, as I have already said, there are honorable exceptions.

In September the diminution continued, the total number of boxes landed during that month being 1184, as against 1924 in August. To this number the small fleet on the Terschelling ground contributed the largest number. I understand that the vessels ceased "fleeting" some time during this month, but some of them continued to work the same ground while "single boating." Only one steam trawler brought in small plaice—viz. 295 boxes in three trips.

In October the total falls suddenly to 295 boxes, of which 133 were contributed by a Hamburg steam trawler, fishing to and from Grimsby on account of the cholera at home. Before this the German steam-vessels do not seem to have molested the small plaice much. I do not know whence the bulk of the small fish caught this month was derived, except that part, and I believe a large part, came from the Terschelling ground, where the very minute fish are not found. Examination of the catches brought in from this ground during the whole of the season failed to reveal any noticeable increase in size, and since we know that individual fish grow rather rapidly, the inference is that there is a constant succession, the fish passing from shallow to deeper water as they grow larger.

October is the last month (for 1892) of the small plaice fishery, and, indeed, it may be said that the season was practically over in September. In November and December no boxes containing only small fish were observed in the market.

About October a migration of fine plaice to the grounds lying off the "Holman" (Hantsholm) lighthouse is always expected, and occurred in 1892 as usual. In the same neighbourhood in the summer only small fish can now be obtained, and these rather closer inshore than the fine autumn fish; but, as I have been told by many old fishermen, all the grounds north of the Horn Reef formerly yielded fine fish in the summer, without any very small ones; thus forming a contrast to the more southern grounds along the east coast, where small fish seem always to have abounded, though plenty of fine examples are said to have been also obtainable. In fact, my information goes to the effect that the wholesale destruction of small fish on these grounds had been going on every summer for many years (ever since about 1830, when British trawling vessels seem first to have taken to fishing the Dutch grounds) before it attracted public attention. It escaped notice for this reason,—that as long as the supply of fine fish held out, the small ones, which were at least as numerous as they are now, were shovelled overboard, and thus never made their appearance in the market. The same thing is going on at the present day, only the items of the catch which are too small for the present market are indeed minute.

In January, 1893, twenty-one boxes, and in February forty-seven boxes of small plaice were observed in the market, but of these a considerable proportion were not derived from Grimsby boats. The fish had been culled out from large consignments of plaice sent by rail from Lowestoft, but I could not discover what were the proportions of large and small in the whole consignment, nor was it possible to trace their origin any further than the port at which they were landed. The trawlers from Yarmouth, Lowestoft, Barking, &c., usually fish to the westward of the Terschelling ground during the winter, but I have no knowledge as to the quality of the fish caught there. Early in March a Grimsby steam trawler visited the Dutch and German coasts, but brought in no small plaice. About the middle of the same month two vessels visited the same or adjacent grounds and landed moderate catches of plaice, mostly answering to the market description of "half-fish," *i. e.* short of the biological standard of maturity, but too large to be classified in this connection as small. Thus it would appear that the "body" of small fish is not yet on the eastern trawling-grounds, but, if last year's experience be repeated, they may be expected to make their appearance there early in April.

Whilst enumerating the quantities of small plaice landed during the different months of the year it may be as well to give the quantities of larger fish landed at the same time. This cannot be done with absolute accuracy, as the only possible way of recovering the total quantity is by accepting the returns furnished by the Board of Trade statisticians. I found it impossible last year to take account of all fish, even of any one important species, landed at the pontoon; and the method adopted by the statistician, who bases his estimate mainly on information furnished by the railway company as to the amount despatched on their line, depends for its accuracy on the correctness of the deductions made for weight of packing material, additions for difference in condition of fish, home consumption, &c.

Now the fish arrives at the pontoon either whole ("live") or with the viscera removed. It may leave Grimsby in almost any condition. It may be sent off *in statu quo*, or may be cleaned, beheaded, boned; only a small part of it may be worth transmission. It may be wet or dried, pickled or smoked; it may come in as a codling, and go out as a "Finnon" haddock!—be caught as the head of Anarrhichas and tail of Lophius, and go out as the masseter muscles of Raia! The last instance, however, would not affect the correctness of the return, as these three kinds are not thought by the Board of Trade authorities to be worthy of discrimination, but go, in company with lemon soles, witches, conger-eels, dabs, &c., to swell the column for "All other except shellfish."

It will be admitted that the circumstances noticed above furnish rich opportunities of error, and in my opinion the statisticians deserve the greatest credit for the large degree of accuracy which I believe to exist in their returns.

These returns deal with values and weights only, but the latter can easily be converted into boxes, the term of which I have hitherto made use in these reports. Nine stone may be taken as the average weight of fish in a box packed in the ordinary manner for sale in the market, that is with the fish piled to some height above the top of the box. A box which is only filled up to the top is spoken of as a "level." No other measures are now in use in the Grimsby market, turbot, brill, and halibut, and large round-fish being sold either separately, or in the rows in which they are laid out when first landed. Inferior fish, such as gurnards, are generally sold in heaps.

The subjoined table gives the figures arrived at by accepting the Board of Trade totals expressed in the first column. They are intended here to comprise only North Sea fish.

1892. Month.	1. Total weight. cwt.	2. Total number of boxes.	3. Boxes containing only "small" fish.	4. Other boxes.	5. Percentage of total formed by No. 3.
April . .	11,000	9,777	1,836	7,941	18
May . . .	12,000	10,666	830	9,836	7
*June . .	10,400	9,244	3,470	5,774	38
*July . . .	17,000	15,111	2,059	13,052	13
*August . .	10,600	9,422	1,924	7,498	24
September .	15,000	13,333	1,184	12,149	8
October . .	20,000	17,777	295	17,482	1

It will be noticed on consulting columns 3 and 5 that the gradual diminution of the actual numbers of boxes of "small" is not accompanied by a similarly regular decline in the same item when converted into percentages of the total. This is, I think, to some extent due to my having deducted too little for the Iceland fishery in July and August; but there must also be other causes, of which I have no knowledge. Apart from abundance or scarcity of fish there must always be some irregularity in the supply, as individual boats are constantly shifting from the pursuit of one species to that of another, according to the luck or inclination of the skippers.

It must be borne in mind that the boxes of "small" are very far from exhausting the number of undersized fish brought to market.

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* In June, July, and August I have deducted 1000 cwt. from the Board of Trade totals as representing a very moderate estimate of 800 boxes, in this case packed so as to contain 10 st., derived from the Iceland grounds, and therefore not products of the North Sea Fishery proper.

In fact, it is my experience that, taking one box with another, at least a third of the fish contained in the boxes enumerated in column 4 fail to reach the proposed biological standard of maturity, and, indeed, we should still be in no danger of exaggeration if we were to assume that that proportion is actually sexually immature. I am here speaking of a proportion of numbers, which is a very different matter from one of weight or bulk, such as is given in the case of boxes of "small" in column 5.

We might certainly arrive approximately at the proportional number of small fish derived from all sources by converting boxes into numbers contained therein, but I have to confess that my confidence in the accuracy of column 1 is not such as to tempt me to elaborate further on that basis. Certain items of work, which during last season engrossed a great deal of time, having now been dealt with, it is my intention during the forthcoming small-fish season to take steps for obtaining statistical information which shall not be dependent for its accuracy on the correctness of any estimate whatsoever.

Turbot.—So long as boats continued to work the eastern grounds for small plaice last year, they continued to bring in with them a large proportion of immature turbot, not essentially differing from that noticed for the earlier months in the last number of the Journal (p. 383). As soon as the eastern grounds were abandoned immature turbot ceased to be a conspicuous feature in the market. It is not, however, clear that the small turbot leave the eastern grounds at the same time as the plaice, or, if they do so, it would appear that they may return earlier. Thus a smack returned on the 3rd March, 1893, from the Dutch and German grounds, bringing fifty-five turbot, of which thirty-five were immature, but no plaice. On the other hand, another smack, also from "across," brought in a good lot of small plaice, but no considerable number of small turbot.

It may be not uninteresting to compare the price of turbot now with that which could be obtained some twenty-five years ago.

From an account belonging to my friend Mr. G. L. Alward I find that in April, 1867, two boxes of turbot were sold in Billingsgate Market for £2. On one day in March of the present year the price in Grimsby Market rose as high as 2*s*. per lb. We may reckon about 9 st. of fish to a box, which at 2*s*. per lb. would make the price £25 4*s*. for the two boxes. The comparison is not altogether a fair one, as Mr. Alward tells me that prices were extraordinarily low on the occasion mentioned even for that period;* whereas 2*s*. per lb. is the highest price, at first hand, of which I have heard even in Lent in recent years. To what extent the difference is explicable by decrease of fish and increase of demand respectively it is hard to say, but surely the former factor is not the least significant in the case.

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* Nevertheless large turbot were often sold for only 1*s*. each.

Soles.—Immature soles have not been a conspicuous feature amongst the catch of large trawling vessels belonging to this port at any time since I have been at Grimsby, but on the 21st February of the present year a consignment of soles from Lowestoft included about 200 pairs, measuring from 6¾ to 7¾ inches. On the following day a similar consignment was also received in the market. I have no actual knowledge as to where or how these fish were caught, but am informed that they were most probably taken by Lowestoft boats off the Hook of Holland, which appears to be the earliest ground for soles on that coast, or near the English coast.

Cod.—Local custom divides the individuals of this species into four sizes. Up to about 20 inches they are "codling," thereafter they rank as "sprags," until at about 30 inches the dignity of "half-cod" is attained. Larger fish are spoken of simply as cod. A sprag is therefore on the borderland of sexual maturity, a condition of which all codling fall short.

My own experience on the North Sea grounds, and the records of a great number of hauls kept for me by my friends amongst the trawling fraternity, point to the fact that rather more immature than mature fish are caught by trawling, but that the number during most months of the year and on most grounds is not such as to call for special attention. On occasions, when a shoal of herring or some less patent cause has attracted large cod to a particular ground, good takes are often made; but, as a general rule, the species appears to be, in point of numbers, rather an insignificant product of the fishery. Nevertheless, having regard to the high price commanded by fish of fair size, and their relative and, as is asserted, increasing scarcity, it is obvious that the destruction of young and comparatively worthless examples is a matter to be exceedingly regretted, though it may not be easy to suggest a remedy. The most notable instance of their destruction which has come under my own observation occurred on the Great Fisher Bank in July. A great part of this important ground is covered by a very dense growth of *Flustra foliacea* (locally termed "scented" or "lemon weed"), and the net often brought up a cart-load or more of it. Very few large or even fair-sized codling were taken, but whenever the net came near the surface any number of minute examples, 2 to 4 inches long, would float out from among the Flustra, dead or dying, marking the wake of the ship with the gleam of their silvery abdomens. Others would be found when the net was got in, and though it was of course a difficult matter to count them, I should say that some hundreds must have perished with each haul on the "weed"-covered part of the ground. It is evident that a number of vessels working in this locality must effect a serious injury to the species, the smallest members of which appear to suffer sufficient persecution from a natural enemy, the long rough dab.

Observations of fish brought to market up to the end of the autumn of 1892 supported the conclusion derived from consideration of records kept at sea, viz. that no very considerable number of codling (apart from the very small examples which suffered in the way I have just indicated) were destroyed. A boat would bring in one or two boxes, or there would be a certain number of codling mixed up with the haddock, but I never noticed any large quantity. In the winter, however, there was a marked change, and codling began to be quite a conspicuous feature in the market. A number of experienced men have drawn my attention to this as something quite unprecedented, though I understand it is not unusual for fish of this sort to be rather more abundant in winter than at other times of the year.

The number of boxes landed, from the time at which they first became noticeable, is as follows :

1892	November (last week only)	180	boxes.
	December	825	,,
1893	January	1605	,,
	February	1763	,,
	March 1st to 20th	896	,,
	Total	4469	,,

There are about 100 fish in a box, so that the above figures represent over 400,000 fish. They are from 12 to 20 inches in length, but an odd fish amongst several boxes may reach a length of 25 inches or a little more. Thus all but an utterly insignificant proportion are sexually immature. A box fetches about 5*s.* 6*d.*, more or less, according to the state of the market, and is therefore worth not very much more than one full-grown fish in good condition.

By far the greater number of these fish were caught by a firm of steam trawlers, which, from their habit of making short trips and never going very far off port, are locally termed " inshore " boats, though it must not be imagined that the grounds they fish are within the three-mile limit or anywhere near it. Such vessels are also known as " Cleethorpers," the name conveying, as I gather, a delicate insinuation on the part of more adventurous spirits that they never get beyond the mouth of the Humber. Fish of all sorts having become very scarce during the winter, it appears that these vessels, finding a fair supply of codling at and near a ground known as the " Yorkshire Hole," continued to fish there regularly in default of prospects of more legitimate success elsewhere. The pecuniary results seem to have been sufficient to attract other vessels, steam and sailing, to the same grounds, which thus furnished by far the greater part of the codling landed up to the last week of February. The greatest number landed by any vessel in a single trip was 122 boxes. A " voyage " of 23 boxes from the Great Fisher Bank at the end of January, one of 48 from " Botney Gut," and two of 78 and 104 from the " N. N. E. Hole " in February, assisted to swell the total, but the two last grounds are not far from the Yorkshire Hole. Of course the contributions from all other grounds, however insignificant individually, form collectively a sensible quantity.

Towards the end of February the chief agents in this matter shifted to the (Flamborough) " Head ground," attracted by good catches of plaice which were being made there. A diminution in the number landed has therefore been noticed, though at first codling were rather abundant on that ground also, one vessel bringing in a " voyage " of 40 boxes. They have since become less abundant, 13 boxes being the average catch of six steam trawlers at the end of the period with which my records deal. There is also, I think, a steady diminution on other grounds, though a good number still continue to be brought in. The fish appear to be scattering, though the decrease may be due in part to an involuntary migration to Grimsby. At any rate, there can be no doubt that the injury inflicted this winter on the cod fishery in general is out of all proportion to the profit derived.

Haddock.—North Sea haddock are divided by Grimsby fishermen into large and small, the limit between the two lying at about twelve inches. They are always cleaned at sea, and the larger fish become either " kits," *i. e.* suitable for packing in tubs of the same name, or " gibbers," according to the method in which the offal is removed. In " gibbing " the viscera are withdrawn through an incision along the abdomen, which does not extend as far forward as the isthmus, and therefore spoils the external appearance less than the ordinary process to which " kit " and small fish are subjected. Whilst the larger fish are mostly cured, the ultimate destiny of the small is the fried-fish shop. Consequently, whilst boxes of the former may contain a considerable admixture of sizes, the latter are always packed separately. On this account I have found it convenient to adopt the local standard of size in recording the quantity of undersized fish landed. Of course a certain number of immature fish, mixed up with others in boxes of " kit," are excluded, but I do not see that it is possible to recover the exact or even approximate numbers. It must therefore be remembered that while all the fish included in the figures given below are short of the provisional biological standard, in point of fact less than 13 inches in length, the figures are not intended to be inclusive of all sexually immature fish.

Being occupied with other matters, I made no attempt to record the quantity landed during the earlier part of 1892, but noticed that the quantity decreased towards the summer and began to increase again in the autumn. My statistical inquiries were commenced towards the end of September.

The figures are as follows :

1892	September (last week only)	366	boxes.
	October	542	,,
	November	1335	,,
	December	1440	,,
1893	January	1416	,,
	February	1471	,,
	March 1st to 20th	1551	,,

As a rule, no considerable number of haddock in the market are of less than ten inches, the limit advocated by Dr. Fulton, but once or twice during the summer tug-boats not belonging to the regular fishing fleet brought in a good many smaller fish, mixed up with small whitings, gurnards, lemon soles, and dabs. I am not sure where they were caught, but was given to understand that they were probably from some of the "roughs" off the Yorkshire coast. Mr. Cunningham, in the last number of this Journal (p. 359), in estimating the age of some of these specimens, places the limit between those of one and two years old at 9 inches.

My own experience at sea, confined so far as haddock grounds are concerned to the spring and summer, is that many more mature than immature fish are trawled during that period, and the bulk of the evidence afforded by records kept for me by trawling skippers supports the same conclusion, and extends it to all seasons of the year. Still in several hauls, in each case on some part of the Dogger Bank, more small than large fish seem to have been caught. I have never trawled many haddock so small as to be unmarketable, but have got a few very small ones entangled amongst Flustra. On this occasion no sizes intermediate between 3½ and 10 inches were represented. From various grounds I have occasionally received a number of very small fish, specially saved for me, but usually when these were caught there were no large fish. Similarly, it is the common experience of liners on the east coast of Scotland that the large and very small fish are not taken on the same ground at the same time.

We know that the haddock is gregarious to a greater extent even than the cod, though our information as to its earlier life-history remains singularly meagre. Speaking generally, we may say that the shoals containing large fish—in fact, the only shoals of which we have definite knowledge—contain also fish of all sizes that are marketable, and some which are usually considered too small to be included in this definition; but the very small fish live apart. The explanation seems to be that young fish do not join the shoals until they have attained such a size as enables them to prey on similar organisms, and to keep up with the frequent and very rapid migrations of their larger brethren. Such size or condition appears to be reached at about 8 to 10 inches. Now, if the young haddock attains a length of about 6 to 9 inches in the first year of its life, it is evident that, as this fish is an early spawner, there will be a considerable accession of young fish to the shoals in the winter months. The period during which such increase would be noticeable might be expected to be somewhat more extended than that during which the species spawns, since it must be some time before these recruits attain a size which places them outside the category of "small" haddock. It remains to be seen whether a continuation of statistical inquiries will confirm the general impression, and my own, that small fish are more plentiful in the winter and early spring than at other times of the year; but if such prove to be the case, the above speculations as to the cause may be not devoid of interest.

Shrimp-trawling.

It will be remembered that in my last report I alluded to a bye-law of the North-eastern Sea Fisheries District Committee which prohibited the use of shrimp-trawls in the Humber, and in certain other inshore waters with which I have no acquaintance, between the beginning of April and the end of September, and altogether prohibited the use of fish-trawls in the same waters. I also found it necessary, owing to the very general disregard of such part of the regulation as referred to fish-trawls, and the difficulty of discriminating in the market between Humber fish taken by the different kinds of trawl, to include all such fish in one category.

Since the report was published I have had an opportunity of obtaining a more intimate acquaintance with the conditions of the industry. Complaints were numerous on the part of those dependent, wholly or in part, on the Humber fisheries, that the season closed by the bye-law was too long, and a petition was presented to the Committee, praying that shrimp-trawling might be allowed from the beginning of March to the end of October; in other words, that the open season might be extended by a month at each end.

With a view to satisfy themselves as to the wisdom of granting such concession, the Committee asked me to carry out a series of investigations on the subject, for which purpose Mr. J. W. Woodall, a member of the Committee, and one whose interest in the welfare of our fisheries as well as in marine biology for its own sake is too widely known to need more than a passing reference here, offered the use of his steam yacht, the "Vallota," R.Y.Y.C., for a month. The Council of this Association accorded the necessary permission, and I propose here to give a brief account of the work done and the conclusions arrived at.

The "Vallota" draws only 4 feet of water, and is therefore eminently suited for work in a shallow estuary, such as the Humber. The gear we used consisted of a professional shrimp- or prawn-trawl, beam 13 feet, mesh $\frac{7}{8}$ inch "from knot to knot," or $\frac{7}{16}$ inch square, in cod end. No pockets. Hemp ground-rope $9\frac{3}{4}$ inches in circumference. False bellies of leather, cork, and coarse netting. We also carried a small fish-trawl of ordinary pattern, $17\frac{1}{2}$ feet beam, and a naturalist's trawl, 9 feet beam, of sprat-mesh lined with mosquito net, and fitted with a heavily chained ground-rope.

The services of a professional shrimp- and prawn-trawler were secured to pilot the yacht, point out the different grounds, and work the gear.

The chief object of the investigations was to arrive at a knowledge of the amount of destruction of young fish of valuable kinds which would be likely to ensue from the regular working of the grounds by shrimp- and prawn-trawlers during the season then closed by the Committee's bye-law, or during such part of it as was included in the time when the investigations were carried on, viz. from October 19th to November 17th. For this purpose a number of hauls were made on all the grounds with the professional gear, and the results accurately recorded, the *modus operandi* being as far as possible assimilated to that of the small sailing-boats engaged in the industry. The fish-trawl was used on the grounds affected by sole-trawlers, so as to ascertain the quantity and sizes of fish present during the current season, and also in various parts of the river not usually accessible to sailing-boats, partly with a view to obtaining all possible information as to the distribution of fish in the river, and partly, in conjunction with cod ends of different mesh, to test the relation between size and pattern of mesh and size of fish caught. As these operations do not intimately concern the subject under discussion, I shall not refer to them further in this place. The naturalist's trawl was used at the same time as the fish- and shrimp-trawls, in order to find out what fish or other organisms passed through the meshes or beneath the ground-rope of those engines.

Fishing-grounds.—The same boats and gear are employed for the capture of both shrimps (*Crangon vulgaris*) and prawns (*Pandalus annulicornis*), but as the latter are the more valuable, they receive by far the greatest share of attention.

Subjoined is a list of the grounds, with local names, and soundings at low water.

Prawn Grounds.

"Inside the Middle Sand"	23 to 50 feet.
"Outside the Trinity Sand"	30 to 70 ,,
(Clee) "Ness Channel"	13 to 40 ,,
"Back of the (Clee) Ness"	15 to 30 ,,
"Tetney"	24 to 30 ,,

Shrimp Grounds.

"Paull Middle" (Sand)	8 to 16 feet.
"Sand Haile"	8 to 16 ,,

Shrimps are represented to some extent on all the grounds, but very few large prawns are present on the shrimp grounds.

Owing to the prevalence of wrecks and other obstructions, such as clay banks and accumulations of "ross" (Sabellaria), the grounds are very sharply defined, so that a sailing boat is absolutely dependent on favorable conditions of weather to allow her to work at all. Except at slack water, it is only possible for her to trawl with the tide, and it will be readily understood that it is not every day that the wind allows a sailing boat to keep her course drifting along a very narrow strip of ground. In the "Vallota," owing to her large size and comparatively high freeboard, it was difficult to go slow enough when wind and tide happened to be in the same direction. As a rule, however, we were fortunate in being able to work at the required speed, and, when the wind was abeam, an occasional use of the engines enabled us to keep our course in a manner impossible to a sailing vessel, while at slack water we could, of course, choose our own direction.

Method of working gear.—To avoid damage to the net professional shrimp-trawlers attach one buoy by a long line to the cod end, and another to the end of the warp, which is made fast to the boat by a stop of small cord. Thus, if any obstruction is met with, the stop will break before much damage is done to the net, which can afterwards be lifted by whichever end is most convenient.

Capture of fish.—In dealing with the results it will be necessary to consider the shrimping and prawning grounds separately, since, as might be expected from the difference in soundings, they differ considerably from each other in relation to the capture of small fish. Further, the different prawning grounds are not all alike in this respect.

The fish of any known value which we met with consisted of sole (*Solea vulgaris*), plaice, common dab, lemon sole, flounder, cod, whiting, whiting-pout, sprats, thornback, and spotted ray (*Raia maculata*). Besides these we took a number of unmarketable kinds, viz. "hard-heads" (*Cottus scorpius*), "bull-routs" (*Agonus cataphractus*), "gobblers" (*Liparis Montagui*), gunnels (*Centronotus gunnellus*), viviparous blennies (*Zoarces viviparus*), "eel-pouts" (*Motella mustela*), "Williams" or "sweet fish" (*Gobius minutus*), a few *Raninus raniceps*, and one long rough dab: the vernacular names in inverted commas are those in local use; some species have no local designation.

I have never come across a solenette (*Solea lutea*) in the Humber, and am pretty certain that the species does not exist there. Hence the confusion which is so abundantly evident in the mind of the fisherman and amateur fishery expert wherever solenettes and young common soles are found together does not exist in this locality.

"Trinity" ground.—As this is the most important ground, especially at the season during which our operations were carried on, we devoted especial attention to it. In eleven hauls with the professional gear we always obtained a fair catch of prawns, considering the lateness of the season.

Only nine soles were taken, four hauls being blank so far as this species was concerned. The largest number taken in any one haul was two. The fish measured as follows: two less than 2 inches, two small, exact size not recorded, two at 5½ inches, one at 9½ inches, and one at 13½ inches.

Early in October I had made the discovery that young lemon soles occur in the Humber in autumn, all previous information having induced a general belief amongst those interested in the matter that the early life of this form was passed in comparatively deep water, and consequently at some distance from land on most coasts. Only a few were taken on the occasion referred to, and it was therefore with the greatest interest that we found fresh specimens yielded by almost every haul on the ground now under consideration. The number was in no case large, sixteen being the most in one haul. Another yielded eleven, but no other more than seven. The smallest fish measured 2 inches in total length, and the usual size was from 2½ to 3½ inches; a few were taken at sizes ranging from that last mentioned up to 8½ inches, and there was one specimen of 11 inches.

Plaice were very scarce; in the eleven hauls we only got eight fish, viz. five in one haul, one each in other three, and none in the remainder. Six of these fish measured from 5½ to 9½ inches, and the others 14½ and 17½ inches respectively. I may add that this last is the only instance of the capture of a fair-sized plaice in the Humber that has come under my notice.

Common dabs were more numerous. They occurred in October in the first eight hauls, but were absent from the remaining three, which were made in November, but I do not know that we are justified in attaching much importance to this circumstance. The largest number taken in a haul was twenty, no other haul yielding more than seven. With the exception of one translucent metamorphosing example of ½ an inch, the smallest size taken was 1½ inches, the largest being 10½ inches. Taking 7 inches as a convenient limit for dividing large and small of this species, about two thirds of the fish caught must be included in the last category.

Small cod and whiting were always taken. The average of eight hauls (the exact number taken in the remainder was not recorded) was 79 of the former and 78 of the latter, but the two kinds did not occur with equal regularity. Thus the extreme numbers taken in single hauls were for cod, 15 and 179; and for whiting, 36 and 156. All sizes of cod from 2½ to 7 inches were present, but the majority were under 5 inches. A solitary example measured 21 inches. Whiting were from 3 to 7½ inches, but mostly less than 6 inches.

Except a small ray, and an inconsiderable number of sprats, no other fish of known value occurred on this ground.

All the kinds of unmarketable fish which I have mentioned above were represented, but Liparis predominated. Small Cotti and half-grown Agoni and Gobies were also abundant.

Besides the prawns, which exhibited a very deep red colour whenever we dropped into the 9-fathom hole near the lower end of the ground, a few shrimps were always taken. Other Invertebrates included a few sun-stars (*S. papposa*) and common star-fish, a few shore-crabs and common hermits, a good many swimmer-crabs (*P. holsatus*), masses of "ross" (*Sabellaria alveolata*), and a few whelks. A good many mussels would occur when we kept rather too close to the Trinity Sand. A little Delesseria was the only algoid noticed.

It appears from the above that, save for a sprinkling of lemon soles and an occasional irruption of common dabs, this ground is very little affected by flat-fish, small or large, at the time when our investigations were made. On the other hand, it is evident that young cod and whiting must be extensively trawled by prawners at that season, should the conditions of their distribution be alike in all years.

"Middle Sand" ground.—This is an important ground earlier in

the season, but, at the time we visited it, yielded very few prawns. Only three hauls were made there.

With the exception of lemon soles, which were not represented, the supply of flat-fish was much the same as on the last ground. Soles were only taken in one haul, viz. three from $2\frac{7}{8}$ to $6\frac{1}{8}$ inches. Plaice occurred also in only one haul, viz. four at from $2\frac{1}{4}$ to $4\frac{1}{4}$ inches. Common dabs were absent from one haul; in another twenty-seven were taken, the sizes ranging from $1\frac{1}{4}$ to $8\frac{1}{2}$ inches, but all but four were less than 7 inches. The number taken in the remaining haul is not recorded; it was not considerable.

Small cod and whiting were about as numerous as on the last ground. Of unmarketable fish, Liparis were less numerous, as might be expected from the comparative scarcity of their prey, the prawns. Other conditions were much the same as on the Trinity ground.

"Ness Channel" ground.—This ground seems to rank next to the two foregoing in importance, but yielded only very moderate catches of prawns when worked by the "Vallota." Five hauls were made, but of these one resulted in a foul net, and in two others we came fast. The ground is very intricate, and can only be worked in security in clear weather, as the marks are not easily seen if it is at all hazy.

Flat-fish were poorly represented. No very small soles were taken, the only two captured measuring $9\frac{1}{2}$ and 10 inches respectively. Plaice were not more numerous than on the Trinity ground, and ranged in size from 5 to $9\frac{1}{2}$ inches. Dabs were scarcer than on any other ground, only five from 2 to $7\frac{1}{2}$ inches being taken. Lemon soles occurred in three hauls, five being the largest number taken, the sizes ranging from $2\frac{1}{2}$ to $7\frac{3}{4}$ inches.

Round-fish, viz. young cod and whiting, were numerous in two hauls, but very scarce on the occasions when the net came fast. Probably some escaped, though little else seemed to have been lost.

Of unmarketable fish Cottus, Agonus, and Liparis were the most abundant. A few edible crabs and a good many shrimps were taken.

"Back of the Ness" ground.—This is worked by professional trawlers either in one haul or two. We tried it in both ways, making in all six hauls with the professional gear. A moderate catch of prawns was always obtained, and shrimps were more plentiful than on the grounds that have already been discussed. It appeared that most prawns were yielded by the upper half, the converse holding good with regard to shrimps.

There were very few soles on any part of the ground, four being the largest number taken in any haul. The sizes were from $2\frac{3}{4}$ to $8\frac{3}{4}$ inches. Lemon soles were present in only three hauls, one of which, however, yielded 12 fish, of the usual size. I could not find that they specially affected any particular part of the ground. Plaice and dabs, on the contrary, appeared to be much more abundant on the lower half. Of the former, 35 was the largest number taken in a haul on the whole ground; on the upper half 5, and on the lower half 27 were taken in two consecutive hauls. The same hauls yielded 6 and 38 dabs respectively, whilst 80 were taken in one haul over the whole ground. The sizes of the plaice were from 1¼ to 10¾ inches, most being less than 6 inches, whilst the dabs measured from 1 to 8½ inches, the great majority being less than 7 inches. Small cod and whiting were as plentiful as on other grounds, but the bulk of them appeared to be derived from the lower half. Two whiting-pout, 8 inches in length, were taken on this ground.

Unmarketable fish, including Cottus, Agonus, Liparis, Centronotus, and Gobius, occurred in variable numbers, but it was not noted that they were more plentiful on one part of the ground than another.

A good many sun-stars, hermits, shore and swimmer crabs were taken. Sabellaria was very abundant towards the upper end of the ground. Hydroids were represented by *Thuiaria thuia, Antennularia ramosa, Halecium* sp., &c.

"Tetney" ground.—During the period of our investigations this ground was very effectively closed to trawling by the prevalence of whelkers' gear, the buoys on which are so arranged as to watch only at certain states of tide. Consequently we were unable to use the professional shrimp-trawl there. Early in October, however, Mr. Woodall having kindly lent his yacht for some work in connection with this Society's mesh investigations, several hauls were made on the prawn ground with the naturalist's trawl used to check the results obtained with the fish-trawls.

The take of prawns varied, but was never very large; but of course it is not possible to judge from such a net the results likely to be yielded by one specially designed for the capture of this species.

Small soles were rather abundant, as many as eleven being taken in one haul, though usually the number was less. A few large fish were also present on the ground, but were caught only in the fish-trawl. Very few lemon soles were taken, this form apparently preferring the deeper part of the river, or it may be that the immigration was only just commencing. There were a great many small dabs, over 300 being taken in an hour's haul on one occasion. Twenty-eight small plaice were caught at the same time, but once, when we went rather too close inshore to catch many prawns, we took over 200 small plaice. Generally there were a few small flounders, and once we got a "chicken" turbot, 13 inches in length. Small whiting were as numerous as on the other grounds later in the season, but cod were comparatively scarce, as, indeed, at the end of

September and beginning of October, they proved to be in all parts of the river which we visited.

We sometimes took enormous numbers of half-grown Agonus and Centronotus, while Cottus, Liparis, and Gobius were always fairly plentiful. *Callionymus lyra* ("dragon"), a species not observed on other grounds, occurred pretty often, *Trachinus vipera* less frequently.

The ground includes the site of the old Tetney native oyster bed, but whilst we always got a lot of shells we only once obtained a living native, probably well-nigh the last survivor of its race. Edible crabs were caught now and then, and there was always a large assortment of shore, hermit, and swimmer crabs, and sometimes a few *Hyas araneus*. *Solaster papposa* was rather abundant.

"*Paull Middle*" *ground.*—Of the shrimping grounds this appears to be the most important, as the Paull boats often take a haul over it whilst dropping down with the ebb to the lower reaches of the river. The "Vallota" was only able to make two hauls there. The most productive yielded a quart of shrimps, the rest of the catch consisting of 35 plaice at 1⅞ to 11 inches, 18 dabs at 3 to 8 inches, 250 small whiting, 8 small cod, and a few flounders, besides a few fish of less importance.

"*Sand Haile*" *ground.*—Here we made one haul of an hour's duration, and caught a quart of shrimps and a pint of prawns, some unmarketable fish, and the following:

One sole at 13 inches, and 12 at 3½ to 8½ inches; 1 lemon sole at 6 inches; 554 dabs at 1¼ to 4 inches, and 17 at 4¼ to 7½ inches; 6 plaice at 2 to 2¼ inches, 4 at 5 inches, and 59 at 7 to 13 inches; 115 small cod; 410 small whiting.

Summary of capture of fish.—It will be seen from the detailed statements given above that very few flat-fish are liable to be caught at the season under discussion on the "Trinity," "Middle Sand," and "Ness Channel" prawning grounds; that the upper part of the "Back of the Ness" ground is also comparatively free from flat-fish, but that some quantity may occur on the lower half. It also appears that the most abundant species is the comparatively worthless common dab.

The "Tetney" prawning ground, however, yielded a good many flat-fish, though here again dabs were the chief sufferers; but it must be remembered that this ground was worked with a trawl furnished with a narrow chained ground-rope, specially designed to pick up very small flat-fish, and, so far as I could judge, rather more efficacious for this purpose than the thick hemp rope of the professional shrimp-trawl.

It is, however, evident that great numbers of small cod and whiting are liable to be caught on all the prawning grounds.

Turning to the shrimping grounds, we find a moderate quantity of small flat-fish on Paull Middle, less than on Tetney, but considerably more than on the other prawn grounds; whilst of round-fish, cod are but poorly represented. On the Sand Haile we find a great quantity of flat-fish, very much reduced if we eliminate the dabs.

Destruction of fish.—Having thus dealt with the *capture* of fish on different grounds, it behoves us next to consider how many of them are thereby *destroyed.*

In the ordinary course of the industry, when the trawl comes on board the catch is shot into a box, or on to the deck, and as many as possible of the unsaleable products are picked out by hand and pitched overboard. In this way the Cottus, Liparis, Agonus, crabs, &c., are at once returned to the water, and being all hardy forms, are none the worse. I question very much whether it would not be wiser to destroy the Cottus and Liparis, as their appetite for prawns is inordinate, and they do not appear to subserve any function useful to the fisherman. Swimmer crabs, also, I am inclined to regard as deserving scant consideration. By the same process the whiting and cod, having no value at such a small size, are returned to the sea—to be out of the way, if for no more provident intent. Such flat-fish as are saleable are put aside, the remainder being thrown overboard, at least such as are large enough to attract attention.

The catch of prawns or shrimps, having thus been roughly cleared, is placed on the sieve and riddled over the side of the boat. In this way the smaller prawns and shrimps find their way back to the sea uninjured, and any flat-fish which have previously escaped detection also pass through the wires. The fisherman's object being to get the prawns ready for cooking as soon as possible, it is evident that no time will be lost in getting the unsaleable items of the catch out of the way. It remains to be seen whether the small fish of valuable kinds are in any way the worse for their temporary sojourn in the net and on deck.

No doubt the most delicate forms are the young whiting and cod, but I have found occasion to modify an opinion expressed in the last number of this Journal, that the former would not survive even if immediately returned. Both species are always full of life when they come on board (except such as may have been nipped by a shore or swimmer crab in the net, or gorged by a Cottus), but, if allowed to lie on the deck for any time, very soon become sickly and die. If, however, they are at once thrown overboard they swim away apparently little the worse. With a view to ascertaining the degree of vitality as far as possible, on several occasions the small whiting and cod were thrown into a tub of water instead of overboard, and examined at the end of an hour. The conditions might have been more favorable, as the tub was small, and the water stagnant or only occasionally renewed. The percentage of dead at the end of the hour varied. On one occasion 24 cod and 34 whiting, being the total catch of these species, were placed in the tub. At the end of an hour 21 cod and all the whiting were alive and vigorous, two cod were sickly, and one was dead. The haul on this occasion yielded the usual quantity of prawns, crabs, and lumps of Sabellaria, &c., and I believe the favorable result of the experiment was simply due to the small number of fish, the capacity of the tub being insufficient for the respiration of larger numbers.

Another time the catch included 111 cod and 99 whiting, which were placed in the tub. At the end of an hour (an hour and a half before all were counted) the number of living was 99 cod and 63 whiting. There was some delay in getting the fish into the tub, in which, moreover, they were very much crowded. I do not think that, when fish are returned to the river in the ordinary way, the mortality is ever greater than in this last experiment, and probably it is much less. Other experiments support the conclusion that the cod are more hardy than the whiting, and it was noticed that fish of both species, which appeared moribund when first placed in the water, gradually recovered and ultimately seemed none the worse.

Of course the survival of a fish for an hour cannot be said to prove its absolute recovery, and I had no further means of testing it. The two miles' jolting in a cart involved in conveying fish from the dock to the Cleethorpes tanks proved very fatal to the young cod and whiting, and few of the latter survived it for any length of time. They seemed to suffer much more than the cod from any injury to the skin, such as must necessarily occur from the rostra of the prawns in the net, as well as from handling. Nevertheless, my own opinion, based on the facts which I have recapitulated, is that a large proportion of these returned at once to their natural surroundings escape any serious injury.

Soles and lemon soles, of whatever size, are seldom injured by capture in the shrimp-trawl. Lemon soles are especially hardy. A large number of those which were caught by the "Vallota" were placed in the Cleethorpes tanks. There was slight mortality amongst them for the first few days, probably more due to the journey than to any other cause, but the bulk of them, five months later, are still alive and apparently in excellent health. Soles which had been chafed, either in the net or in handling, ultimately died in the tanks, as at Plymouth (*teste* Mr. J. T. Cunningham, The Common Sole) ; but I do not think it follows that they die if returned to the sea, as soles which have evidently recovered from rather serious injuries are sometimes trawled. Moreover the very small mesh of the shrimp-net appears to lessen the percentage of chafed fish, since it is in struggling to get through larger meshes that injuries to this species usually occur.

Plaice of all sizes suffer no injury from being caught in the shrimp-trawl, and may even be allowed to lie on the deck a considerable time without being any the worse. There has been very little mortality amongst a great many of all sizes which were placed in the Cleethorpes aquarium, whereas I have always experienced a difficulty in getting similar specimens, taken in the shove-net, to live. This may be due to the amount of mud and sand in suspension in the only water available for conveying shove-net specimens to the aquarium, or it may be that the buoy of the shrimp-trawl is beneficial in slightly lifting the cod end off the ground.

Flounders are about as hardy as plaice under similar circumstances.

Dabs, unlike plaice, will not survive a long exposure on deck, the very small specimens being particularly delicate. The mortality amongst those sent to Cleethorpes was at first considerable, though a good many survived. Still, if they are returned to the sea at once, they dart away apparently uninjured. This species appears even more susceptible to injuries arising from chafing than the sole.

Conclusions.—It appears to me that the facts I have set forth show that capture in a shrimp-trawl in the ordinary course of the industry is not essentially injurious to any considerable proportion of young fish of marketable species. If shrimp-trawlers bring to market some small plaice and soles which ought really to be returned to the sea, it is not easy to blame them as long as the same practice, as far as plaice are concerned, is carried on with perfect impunity on an infinitely larger scale by the larger boats which visit the eastern grounds. The remedy for this evil lies so evidently in the imposition of a size-limit applicable to all North Sea fisheries alike that the subject needs no discussion here. Moreover it is apparent that the bulk of the small flat-fish, which, for reasons explained at the time, I found it necessary to class as caught by shrimp-trawling, were in reality derived from the illegal use of fish-trawls.

I have made it, I hope, sufficiently evident that, except off Tetney, flat-fish are so exceedingly scarce on the prawning grounds that there is not even the risk of them being injured thereon.

I am not prepared to say that, in the case of so large a catch of small fish as has been enumerated from the Sand Haile shrimp-ground, some considerable number of small dabs and, to a less extent, plaice, might not have suffered, since to sort them out would take a good time; but as a matter of fact the take on this occasion was so worthless that the fishermen, after picking out the few saleable fish, would, no doubt, have shot the remainder straight overboard. Indeed, both shrimping grounds might be said to be effectually closed, at the time we visited them, by their very unproductiveness.

It must be remembered, also, that whenever any number of small flat-fish occurred, the majority of them were always common dabs, and I would call attention to the opinion expressed by Fulton (Rep. S. F. B., 1890) that it is questionable whether any benefit is to be derived from protecting the young of this species, since it is never of great value, and is a most severe competitor with fish of greater value, *e. g.* soles and plaice, in the matter of food.

In any case it appeared to me that by confining the operation of the closure to the shrimp grounds and the Tetney prawn ground, enough would be done at that season of the year to practically eliminate the risk of destruction of immature flat-fish, whilst the legitimate conduct of the industry would be hardly at all affected thereby.

My recommendations to the Fisheries Committee, in reporting the results of the operations under their auspices, were accordingly made on the above lines, though it was expressly stated that they could only claim to hold good for the period during which the investigations were made. The Committee subsequently repealed their former bye-law, and substituted one which granted the extension of the open season prayed for in the petition to which I have alluded. The use of the shrimp-trawl is therefore now lawful in the waters with which the bye-law deals from the 1st March to the end of October. Though it has not appeared, from the results obtained during last March (1893), that either prawns or shrimps are to be had in sufficient numbers to make their pursuit profitable so early in the season, I have little doubt that the measure will be found on the whole satisfactory, once the enforcement of the existing prohibition against fish trawling shall have removed the imputation which the conduct of a few individuals now allows to rest on the whole fraternity.

For my own part, I have always advocated legislation which deals with the size of fish landed, so far as flat-fish are concerned, rather than with the kind of trawl in which they are caught. Since I am satisfied, from the whole of my experience of the Humber fisheries, that the absolute lack of mature fish in the river would preclude the existence of a legitimate plaice fishery, whilst flounders and dabs are neither sufficiently numerous nor valuable to attract pursuit by themselves, the imposition of a size limit would in effect limit the use of fish-trawls to a short period in the summer when there are some mature soles in the river, if it did not abolish it altogether. This may seem, as it were, an academic discussion, since it is allowed that the same or nearly the same end is attained by either means; but the method I favour would be an effectual safeguard against the abuse of shrimp-trawls for catching small plaice on grounds where neither prawns nor shrimps are to be had. I have found such a practice to be quite feasible, and have no doubt it might be occasionally remunerative, but I must confess that I have no knowledge that the possessors of shrimp-trawls ever divert them from their legitimate prey.

Migrations and spawnings of shrimps and prawns.—Shrimps and prawns seem to arrive at about the same time, viz. the beginning of April, on those grounds in the Humber which they respectively frequent, but the time of arrival, as of departure, is said to vary according to the weather. My own experience is too short to enable me to offer any comments on this point.

The shrimp season for shove-nets usually closes about November, though in very open winters it is said to last longer. The quantity present on the sandy margin, so far as this can be gauged by the takes, is at all times subject to rather sudden variation, and becomes, I believe, especially variable after the end of September. Any diminution in the normal turbidity of the water, more readily perceived by those engaged in the industry than others, is regarded as prejudicial to good catches. The variation of the trawling grounds appears to be even greater than on the margin. Some few shrimps are found in all parts of the river throughout the year, but I do not know what becomes of the remainder in the winter. In digging for lugworms, in February, near high water mark I have found a shrimp, living but very torpid, some few inches below the surface of the sand, at a time when none were obtainable in the shove-net; but it would be unwarrantable to conjecture from this single instance that any considerable number take refuge in this manner during the winter months.

I have made no effort to ascertain the chief spawning period; here, as elsewhere, some shrimps are found carrying ova at all seasons.

Prawns are certainly most abundant in the Humber in summer. It is commonly asserted that a north-westerly gale in autumn has the effect of driving large numbers of them out of the river, and I had the opportunity of observing last year that the number obtainable certainly decreases after such weather. It is also said that once their bellies turn green they begin to leave the river. The green colour is that of the ova attached to the abdominal appendages. We found only a few with spawn at the beginning of October, but later in the same month and in the early part of November the proportion in that condition increased rapidly, whilst there was a considerable decrease in the total number as compared with that obtainable on the same grounds earlier in the season. Our operations were not carried on late enough to show the final disappearance of the species, but I am given to understand that none, or hardly any, are to be found in the Humber in December. I am told, on authority which I have found reliable in other matters, that the prawns, on leaving the Humber, pass to the deeper grounds along the Yorkshire coast, and I know that the species is to be found there in the winter. It has a very wide vertical range, extending well beyond the 100-fathom line on our western coasts.

Recent literature.—The very interesting report of Professor Herdman " On the Lancashire Sea Fisheries Laboratory " (Liverpool, 1893) deals with shrimp-trawling in some detail. From certain statistics collected by Mr. Dawson it is evident that the number of small fish captured in that district by shrimp-trawlers is infinitely greater than anything we have to deal with here. Both shrimps and " shanks " (the local name for our prawn, *Pandalus annulicornis*) appear to be taken by trawlers, but it is not remarked whether there is any difference, as here, in the amount of fish taken in company with these two crustaceans. Mention is made of a prawn-net, presumably a trawl, devised by Mr. Dawson, in which a horizontal bar, 3 inches above the ground, is substituted for the ordinary ground-rope. This is an adaptation, probably an unconscious one, of a principle which has been employed for some years in the bottom tow-nets used at the St. Andrews Marine Laboratory.* The object is to catch prawns and pass over small flat-fish, and, according to Mr. Dawson, this object is achieved. It is also claimed that such a net picks up less débris than one of the ordinary pattern, and therefore fishes better on dirty ground. This is of some importance, as, although a very thick ground-rope is used by Humber fishermen to avoid the capture of " ross," they often catch a good deal, especially early in the season, before the winter's accumulations of the Sabellaria have been to some extent trawled flat. Still it is open to doubt whether a rigid bar would not be an additional difficulty in case of contact with a clay bank, and it would perhaps be better to replace this by a taut rope. In any case I do not see how such a contrivance would lessen the capture of young cod and whiting, which are the only important fish caught in any numbers on our prawn grounds.

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* I understand that a similar contrivance has long been used for fishing rough grounds at Yarmouth.

Shore Fisheries.

Stake-netting.—This industry has again proved a failure at the Cleethorpes station. Nets were first set up there in January, but proved so unproductive that they were soon taken down again. Another trial in February was not more successful. At Humberstone, however, the nets did much better. They were first erected in the early part of January, and by the end of that month tolerable catches were obtained, 16 stone for one day being the largest amount of which I have a note. This was on the 28th of the month. Two days earlier only 5½ stone were found in the nets, after they had been fishing for nine days; there were also, according to my estimate, about two stone of young whiting, from 4 to 6 inches long, besides a few codling about 3½ inches long, and a certain number of plaice from 6 to 8 inches. As after this date the catch of sprats improved so much that it was worth while to lift the nets every day, or sometimes every tide, the number of young whiting became much less noticeable, though the total number destroyed in the same number of days may not have been any less. A few very small plaice, about 1 to 3 inches, were always to be found. The sprats at first comprised a good many that had hardly got beyond the whitebait stage, but towards the end of January and in February the size as well as the numbers increased. More nets were added to the Humberstone station, as many as 30 being down altogether. Thirty-five stone is the largest catch for one tide which I observed. The industry continued to be remunerative up to about the middle of March.

Shove-net and "seine" shrimping.—These industries closed for last year about the end of September, and up to the end of March of the present year shrimps have not been found in sufficient numbers to encourage the fishermen to make a regular start. A few small plaice, however, and a brill of 9 inches were taken in a shrimp-seine on the 10th March. It is worthy of remark that regulations affecting the use of shrimp-trawls apply equally to the shrimp-seine, which is undoubtedly a trawl in spite of its name.

Flat-fish netting.—This is a shore fishery to which I omitted to allude in my last report. The net resembles an ordinary ground seine. It consists of a piece of netting, mesh about the same as in a herring-net, about 20 yards long by a yard high, corked and leaded. The ends are kept open by pieces of wood. The net is worked by two men, each having a rope attached to one end of it, who wade about 10 yards apart along the shallow water near the margin and haul the net behind them. In the summer a considerable number of small plaice and some soles are said to be procurable in this way, but the nets are not very often used. On the only occasion, in February, when I saw one worked, the only thing in the catch worth having was a smelt. As the nets are preferably hauled when the tide is rising no injury is done to the fish which are not saleable.

III. Remedial Measures.

Whatever success may attend the enforcement of a size-limit for flat-fish, there can be no doubt that this remedy will not be efficacious in the case of all round-fish, since (1) there is no area (such as the eastern grounds for small plaice and turbot) exclusively, or almost exclusively, inhabited by immature members; and (2) round-fish are liable to absolute destruction by the mere fact of being caught in the big beam-trawl as at present worked.

I have shown elsewhere that the shrimp-trawl worked in short hauls in shallow water is not in this district (and need not be, I suppose, in any district) particularly injurious to the small round-fish which frequent the areas where such engines are used, but the case in the deep sea is very different.

The approach of the trawl to the surface, even in such very moderate depths as 20 to 30 fathoms, is always marked by the appearance of a number of haddock, which float up with distended air-bladder through the mouth of the net or larger meshes of the "square," and drift helplessly about, a prey to the sea-gulls. When the net is boarded, a number of the smaller haddock are found meshed by the gills and perfectly dead, and very few are particularly lively. I have made efforts to keep those which appeared the healthiest alive in a tub of water, frequently changed, but never with success. I have, however, known a haddock, caught in the deep sea, to be brought into the Cleethorpes aquarium alive, but it died very soon. The skin is very delicate and easily inflamed, but I think the pressure of the weight in the trawl is more fatal, since line-caught haddock, which must get more or less handled, live well enough in the ship's well. Liners find it necessary, unless the fish are from very shallow water, to let the air out of the bladder if they wish the fish to live; and this they do, as also with cod, by a prick with a needle above the pectoral fin, care being taken to avoid the liver. Cod treated in this way live for months in the floating boxes in Grimsby Docks, and I suppose haddock would as well. I am told that even ling, in which the stomach has been everted by the pressure of the air-bladder, can be kept alive by the same means, though in this case the puncture is usually made above the anus. Now this process is well enough for the liner, who finds it tend, moreover, to his immediate profit, but I do not think it is feasible to any very great extent on board a trawler. Though cod are somewhat hardier, haddock, especially small ones, succumb very rapidly if kept out of water; and it is certain that, even if they were attended to before the second trawl (where two are carried) was shot away, many out of a large catch would be beyond surgical aid before it arrived. Flat-fish, on the other hand, are better fitted, by the structure of their gill-covers, to stand exposure to the air, and, in general conformation, to resist pressure, whilst they are, of course, subject to no difficulty arising from an air-bladder. Hence, since only moderate hauls are now to be obtained on any grounds other than the eastern, a large proportion of the undersized members of the hardier kinds would probably survive if returned. Of the less robust species, two, the common and long rough dabs, are of small account, and undersized specimens of the third, the witch, appear to be seldom taken by our trawlers.

To return to round-fish. If, as I hold, no great number of those taken in our large trawls would survive if returned, it would serve no useful purpose to throw them back. Hence the only possible remedy lies in some scheme of mesh restriction, as to which I am not prepared to make suggestions. Though, thanks to much assistance from Mr. Woodall, my inquiries as to relation between size and pattern of mesh and size of fish caught have made considerable progress, I do not consider them as yet complete or conclusive.

It may be pointed out, however, that while it may be hoped that all immature whiting and at least a great proportion of immature haddock may be afforded a reasonable degree of protection by a successful adjustment of the mesh difficulty, there can be no hope by this method of protecting cod beyond a size which is far short of that at which sexual maturity is attained, and of course no net can be devised which will not be liable to get choked by weeds or other rubbish. Every one, I suppose, admits that a fish should have a chance of spawning before it is killed, but I really cannot say how this advantage is to be secured for the codfish. If it were possible to persuade those trawlers who, as I have shown, have been responsible for most of the destruction of codling during the past winter, that it would tend to their ultimate advantage to avoid the grounds most frequented by these fish, one might hope for a sensible mitigation of the evil. It is, however, sufficiently difficult to persuade a man of what is absolutely true, whereas, since adult cod are the prey of the liner rather than the trawler, the proposition perhaps hardly falls into such category.

Monthly Reports on the Fishing in the Neighbourhood of Plymouth.

By

W. L. Calderwood, F.R.S.E.

III.

THE four charts produced in this number, showing as nearly as possible the positions of the various fishing boats in the neighbourhood of Plymouth, are a continuation of the series of charts already introduced in Nos. 3 and 4 of vol. ii. They represent the conditions found during last September, October, November, and December, and complete the year's observations.

September.—The Plymouth area is in this chart shown to be densely covered with fishing craft.

A great line of *mackerel boats* is noticeable stretching along to the east side of the Eddystone. This refers, however, only to the latter part of the month, being most noticeable on the 26th day. The mackerel fishing of the early part of the month was carried on twenty to thirty miles south of the Eddystone, and is therefore not indicated. The small patch of mackerel boats shown five or six miles south of the Eddystone occurred on the 18th night. It is the first indication of the breaking up of the large massed shoals, which is shown more clearly in October and November.

The *whiting boats* were very much scattered throughout the month and difficult to follow.

The *long lining* or bolter fishing shown, took place only in the early part of the month, that shown south of the Eddystone during the first week, that all round the Eddystone on the 12th day. The boats then went along the coast of Cornwall, and at the end of the month were fishing off the Lizard.

October.—The *mackerel fishing* during October was carried on, for the most part, fifteen, twenty, and by some boats thirty miles south of the Eddystone. Towards the end of the month, however, instead of travelling out of all reach as was feared, some shoals struck inshore again. The fishing round the Eddystone shown in the chart for this month occurred on the 25th night. The *trawling* shown to the south of the Eddystone on the "home ground" occurred on the 10th day. A curious patch of *crabbers* is noticeable two to three miles south of the Mewstone.

November.—The *mackerel* marked in last chart are now shown to have been joined by other shoals. Fishing continued a few miles south of Eddystone during most of the month, but on the 19th the position shown just south of the Mewstone was discovered.

On the 5th the *trawlers* worked over the same ground as the mackerel men, and considerable damage to the drift-nets resulted.

A little long lining, which occurred in the early part of the month, is noticeable inside of the Eddystone, the boats having returned from the west. Towards the end of the month, however, the takes being poor, the lines were transferred to Bolt Head.

Only six *crabbing boats* were at work during this month.

December.—It will be noticed that the *mackerel* have now disappeared from the inshore waters. The boats followed them to the eastward, however, as they receded. On the 10th good takes were obtained twenty miles off Salcombe, and also off Start Point.

In coming to the end of the inshore mackerel fishing for another year, it may be well to glance for a moment at the paper I published in a previous number of this Journal on *The Mackerel Fishing of* 1889–90 (vol. ii, No. 1, p. 4). In looking first at the whole season the same general systematic movements can be observed, viz. the appearance of the shoals away off-shore to the eastward of Plymouth, the gradual travelling westward and approach to the shore, the appearance of very large shoals during the height of summer, followed by their division into smaller shoals, which gradually recede during the autumn in the direction from which they came.

That considerable variation takes place as to the exact time when mackerel are found in a definite locality is, of course, to be expected. The causes which influence the natural instinct of the fishes are, no doubt, many. Unfavorable climatic conditions or powerful artificial influences, such as target practice seawards or torpedo and mine firing, may have a direct action on the movements of the fish themselves, or may affect their food so as to cause a similar result.

A continued low or high temperature may retard or accelerate the breeding season, and hence the coming of the fish.

With regard to the fishing seasons of the two years under comparison there seems to be a slight difference in time. In July, 1890, the mackerel began to come close inshore, and during the month of August were taken in considerable quantities in Plymouth Sound. On the 1st of September we read, p. 13, "Mackerel going off into open water. Shoals breaking up."

In July and August of last year (1892), on the other hand, the shoals did not approach the shore, but rather appeared to be leaving the land, so that many fishermen considered the fishing over for the season and took in their drift-nets. In September, however, the usual condition asserted itself, and although the shoals never actually entered Plymouth Sound, yet they were found going through the same general movements in September, October, and November as characterised the fish in August and September of 1890.

To make suggestions as to the causes which produced this result would, in the present state of our knowledge, be mere idle speculation. I desire simply to point out that while the movements of these shoaling fish can be relied upon with tolerable accuracy, one season may be found to be as much as two or three months behind or in advance of another.

With regard to fish which do not move in shoals, it is well-nigh impossible to draw up certain courses, which may be relied upon as indicating their probable movements at any particular period of the year.

The present system of tabulating as nearly as possible the average positions of the boats during each month of the year was commenced by me in January of 1892. By continuing the process during the first few months of this year, it has been possible to compare the conditions found during these months and the early months of last year.

This comparison shows that in studying the movements of the fishes which do not form themselves into shoals, an extreme amount of variation may be present. So much does this appear to be the case that, without observations from a great number of years, it will be impossible to arrive at an accurate mean condition. I do not think it likely, therefore, that a comparison of charts for certain months in different years will be found of any benefit in trying to arrive at a knowledge of the probable movements of fish which do not shoal. At the same time it seems to me to be advisable that, in all localities where target practice seawards is carried on, or where other operations which interfere with fishing may be engaged in, information should continually be collected, so that at any date the positions of the fishing boats, and more specially the small line and crab and lobster boats, could be reported.

In support of this view I gave evidence before the Commission appointed to inquire into Target Practice Seawards, and am pleased to be able to state that in the official return of this Commission, published a short time ago, the suggestion has been advocated, and one of my charts issued as an example.

It seems also possible that a great additional benefit would be obtained, not only to the fishermen but to those firing, if when the order for practice either from a fort or a gunboat was given, some signal or official notice was displayed in the fishing quarter of the adjoining port or fishing village or villages.

It seems certain that if some notification of this kind were given, fewer fishing boats would be found to interrupt operations by appearing in the line of fire.

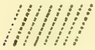
With reference to the collection of particulars as to the positions of the boats, the method adopted has been first of all to form a committee of fishermen representing the various branches of the industry, viz. trawlers, drift-net men, &c., and to obtain regular information from them as to where they themselves and the majority of their neighbours were working. Latterly, the collection of this information has been augmented by the efforts of Roach, the fisherman of the Association.

The great advantages to be derived from telegraphic communication with isolated lighthouses and lightships, so ably advocated by a prominent member of the Marine Biological Association, comes most forcibly into view in this connection. Not only could the indications of the movements of shoals of fish be communicated to the fishermen, but the positions of the fishing boats at work on the grounds within a radius of many miles could most readily be ascertained, and communicated to officers of either service controlling gunnery practice in the locality.

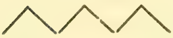
The key to the symbols used in the charts is again repeated. In the last numbers the symbol used to represent long-lining was omitted by mistake. Comparatively few boats are now engaged in this industry at Plymouth. The symbol will be found below.

Key to Symbols used in Monthly Fishery Charts.

//////// = position of herring boats.

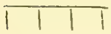
 = ,, of mackerel boats.

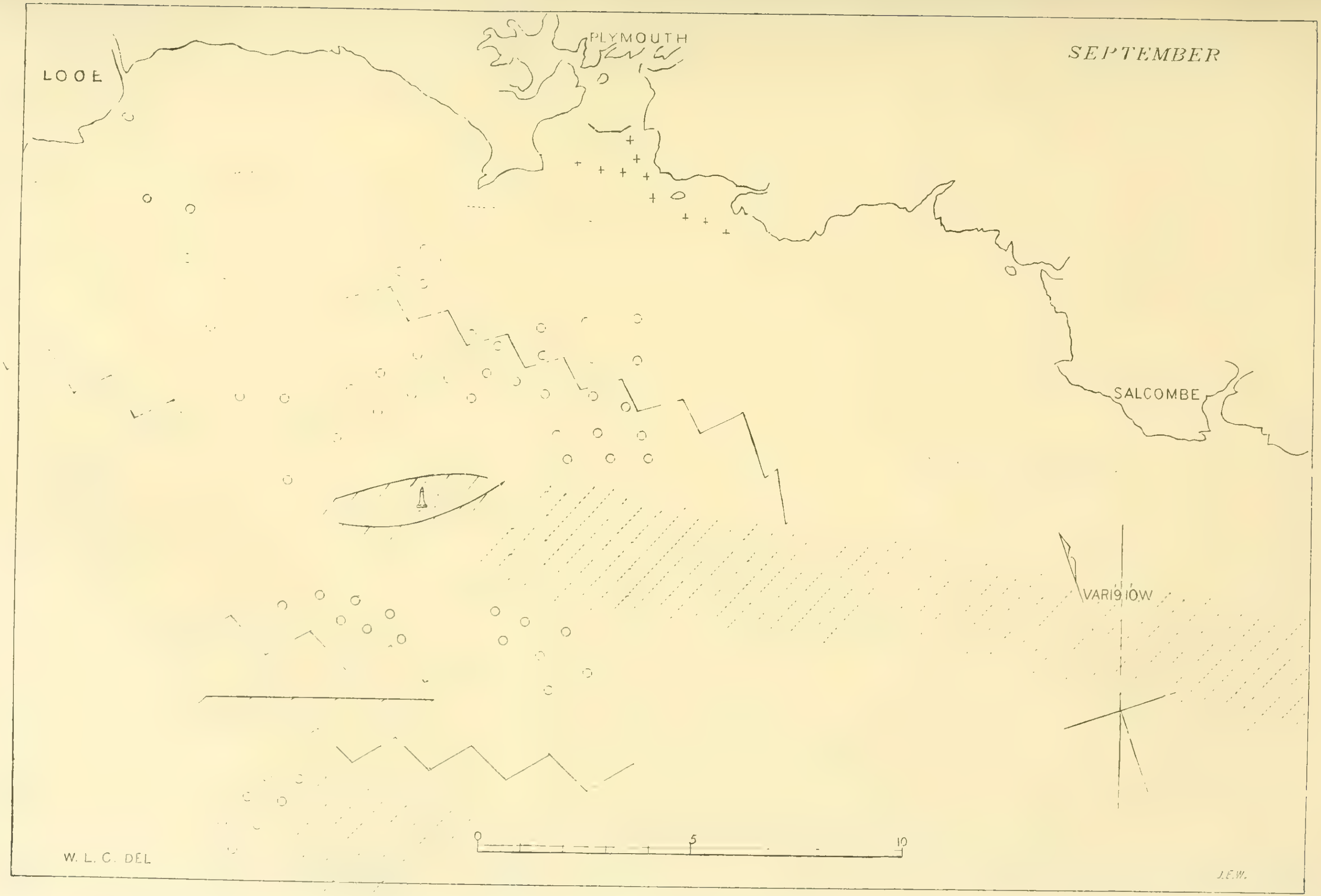
`\\\\\\\` = ,, of pilchard boats.

 = ,, of trawlers.

o o o o = ,, of whiting boats.

+ + + + = ,, of crab and lobster boats.

 = ,, of long line fishing.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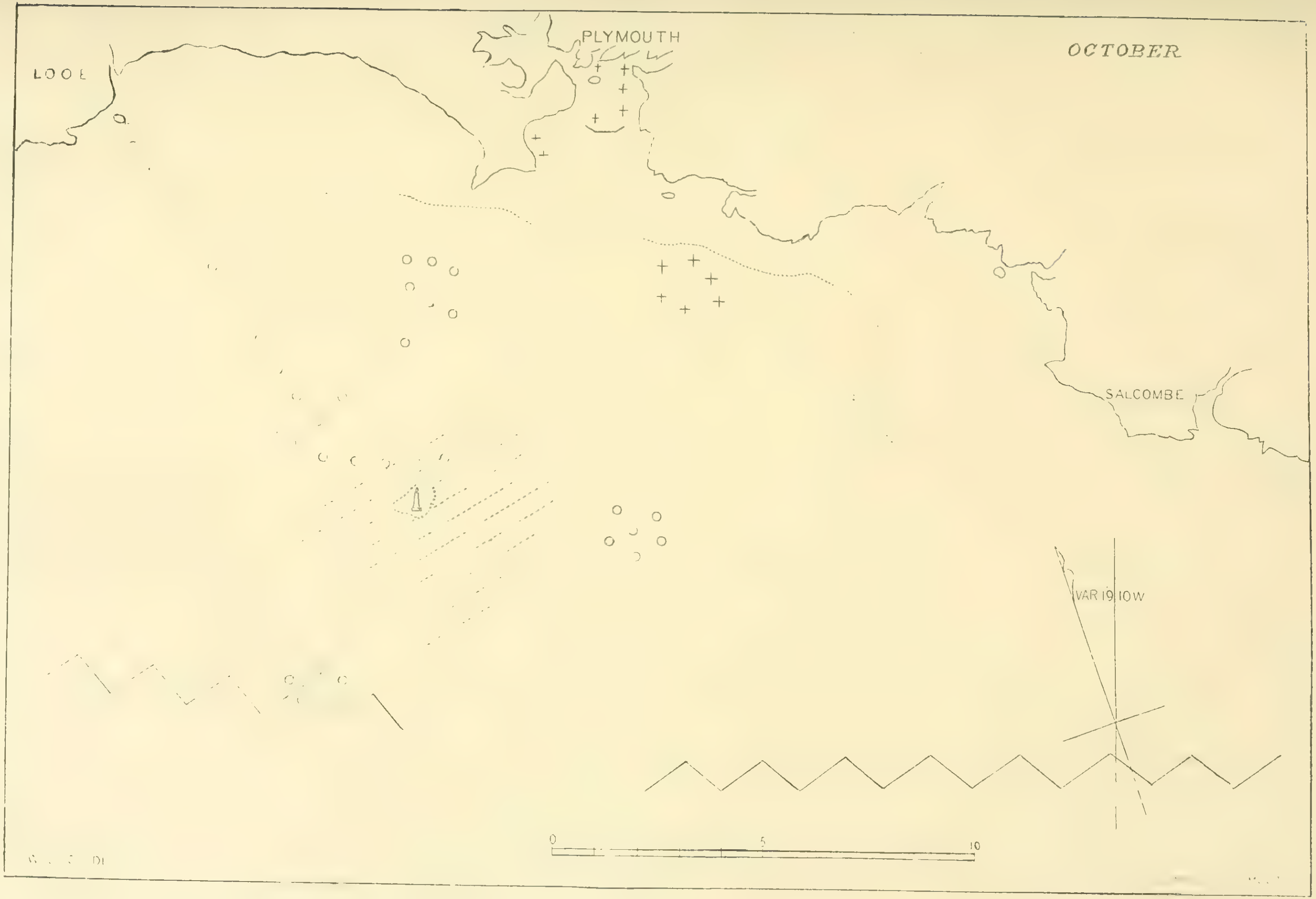
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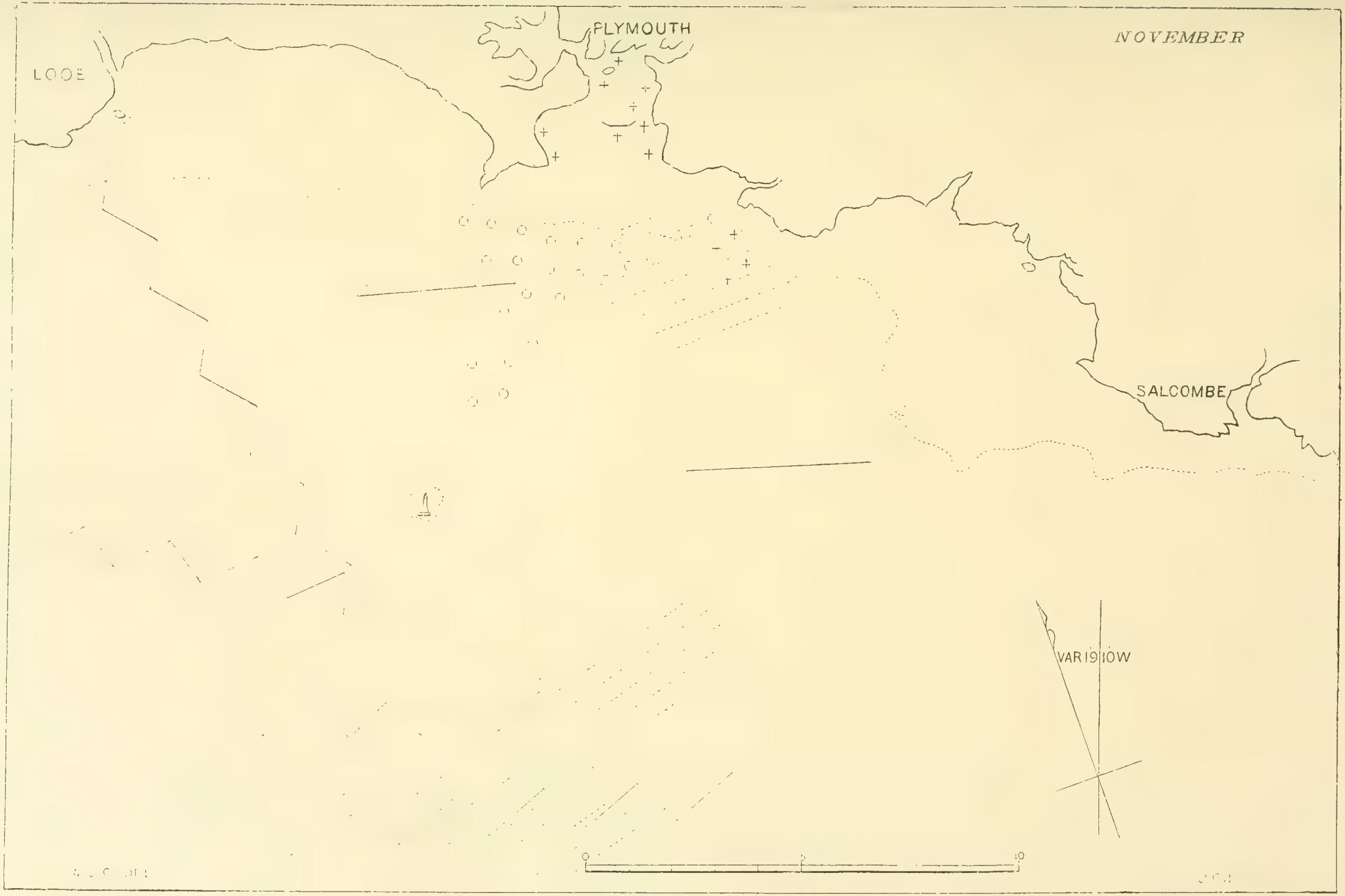
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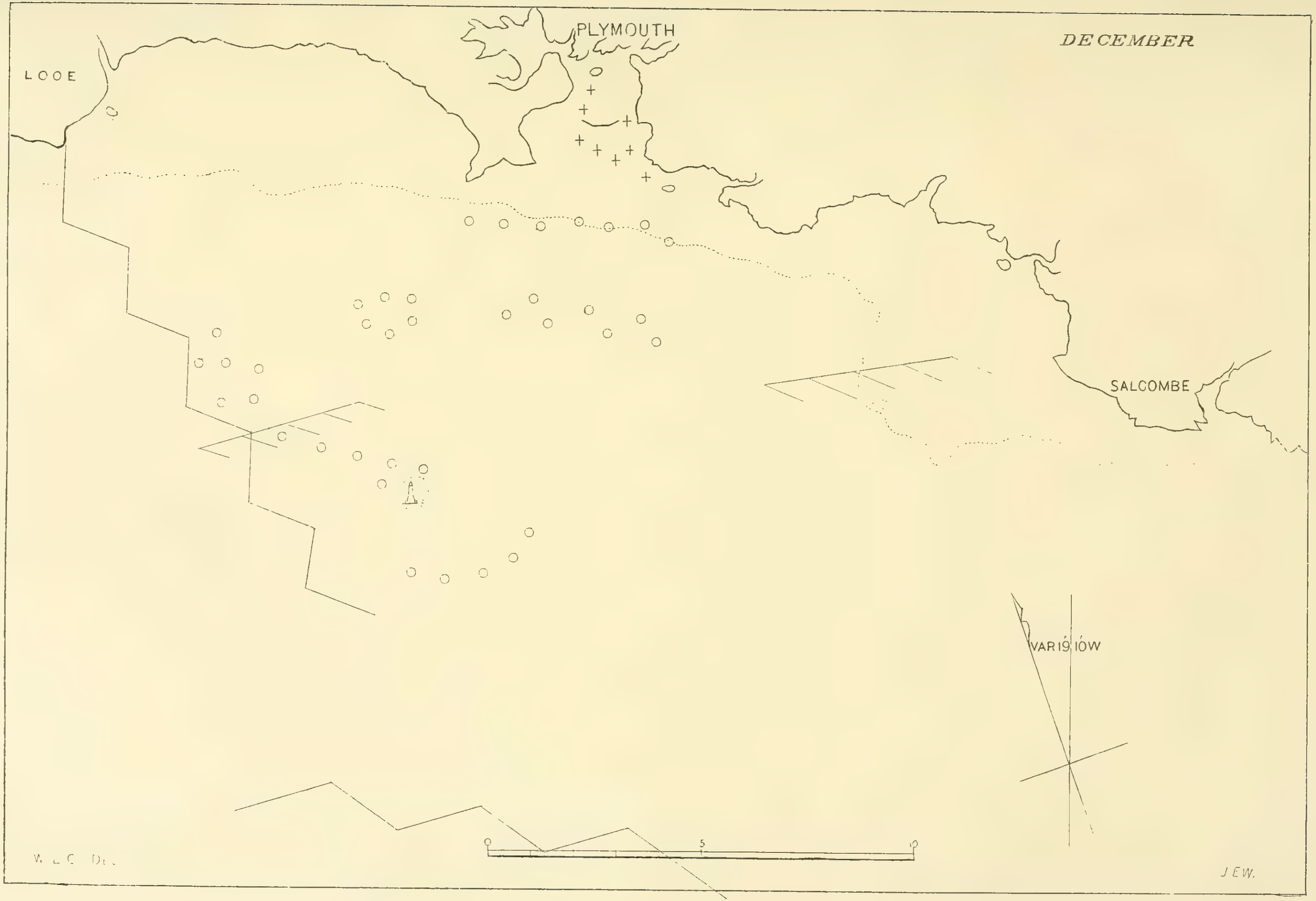
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Researches on the Coloration of the Skins of Flat-fishes.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

In the year 1890 I tried an experiment upon young flounders, with the object of discovering what would be the effect upon the lower sides of the fish if these sides were continually exposed to daylight. Under ordinary conditions the upper side of the fish is dark-coloured, the lower side white ; and the upper side is exposed to light, while the lower side being usually in contact with the ground, and always turned away from the sky, is protected from the light. A connection between the difference of the two sides in relation to light and in coloration naturally suggests itself. If the difference in coloration is due to the difference in the exposure of the sides to light, when the lower side of the fish is kept exposed to the light it ought to become coloured.

When the flounder or other flat-fish is first hatched it has chromatophores on both sides equally, and these chromatophores disappear from the lower side during the metamorphosis. It seemed more likely that illumination of the lower side would prevent to some extent this disappearance, than that it would cause the reappearance of chromatophores on the lower sides of older specimens. My first experiment (described in the Zool. Anzeiger, 1891) consisted, therefore, in taking a few young flounders which had not completed their metamorphosis and rearing them in a glass bottle supported on a plate of glass, underneath which was placed an inclined mirror reflecting the light from a window vertically upwards. I covered the sides and top of the bottle with an opaque cover made first of brown paper, afterwards of cloth, so that the light was to a great extent prevented from entering the bottle in any direction except from the mirror. The rearing of flounders from this stage to maturity, although requiring minute and constant attention, presents no great difficulty. The methods of feeding them and maintaining a circulation of the water containing them were described in this Journal, vol. i, No. 4, 1890. A circulation was kept up in the bottle over the mirror in the experiment by connecting it with another bottle by means of a siphon outflow tube, the aperture of the tube being protected by silk bolting cloth, so that the little fish could not escape.

I was absent from Plymouth in July and the early part of August in 1890. When I returned I noticed that the little flounders continually clung with their lower sides to the darkened sides of the bottle, so that the object for which the apparatus was arranged was to a great extent defeated. I tried to prevent this by confining the fish beneath a horizontal partition of coarse cloth fitted into a cylindrical glass vessel substituted for the bottle, but the cloth did not allow of sufficient renewal of the water beneath it, and the fish were found all dead one morning, having been killed by suffocation. There were thirteen of these fish, and all except one had some pigment on the lower side. The greatest extent of the pigmentation was over the region along the edges of the lower side, from the base of the dorsal and ventral fins inwards, the region corresponding to the muscles of the fins. As far as could be observed in the course of the experiment (it was not possible to make a minute examination without risking the life of the fish), the pigmentation present at the end of the experiment was not due to a retention of the pigment present on the lower side before the transformation of the larval fish was complete, but the original chromatophores had disappeared from the lower side as usual, and had been redeveloped under the action of light.

In my next experiment I took four flounders belonging to the same brood as those of the first experiment. These were some of a number which had been reared under ordinary conditions, which had long passed their transformation and had no pigment on their lower sides. They were about five or six months old, and between 2 and 3 inches long. I removed the covering from the sides of the vessel, and left off using any partition inside it, keeping only an opaque cover on the top. In consequence of this the fish could not protect their lower sides from the light by clinging to the sides of the vessel, and their upper sides were illuminated by light passing through the sides, as well as their lower sides by the light from the mirror. At the beginning of 1891 I had made a wooden tank with a plate-glass bottom, which is still in use, and is shown in the figure illustrating this article. It is 3½ feet long, 2 feet 3 inches broad, and 11 inches deep, and I procured large mirrors to place beneath it. In this tank the four flounders lived and grew. A recurrence of the old difficulty of the fish clinging to the opaque sides took place, and I met this as far as possible by keeping the water in the tank very shallow. After this experiment had lasted six months I observed a commencement of pigmentation on one of the four fish. At the end of June, 1891, one of the four died. I had placed bricks in the tank to keep the fish in the centre of the glass bottom, and this specimen had got fixed between a brick and the side of the tank.

In September one of the three survivors had developed pigment all over the external regions of the lower side; in the other two pigment could not be detected with certainty. In this month another specimen, fortunately not the pigmented one, died. The remaining two lived on till July, 1892, when another died. This one was 23 cm. (about 9 inches) long, and had a large number of separate spots of pigment on the lower side. These spots were of considerable size and dark. Under the microscope they were found to consist of chromatophores exactly similar to those which constitute the pigmentation of the upper side. The fourth specimen is still alive at the present time. It is now three years old, and has lived in the apparatus since September, 1891. It is now deeply pigmented all over the lower side with the exception of a very small area.

There can be no doubt that the pigmentation in this experiment was due to the exposure of the lower sides of the fish to light. There were only four fish used, and two of them which lived long enough developed pigment which continually increased in extent. This is 50 per cent., and although pigment occurs on the lower sides of flounders living under natural conditions as an occasional abnormality, the percentage of such specimens is nothing like 50 per cent. It is important to point out that these four specimens were taken from a number reared in the aquarium in tanks with sand at the bottom, and subjected to no artificial conditions except captivity. In this Journal, vol. ii, No. 3, I have given the result of the examination of all such specimens reared from the brood of 1890. There were ninety specimens altogether, and one of these had a few small patches of pigment on the lower side. These were two years old when examined, and a more rigid control experiment could scarcely be required.

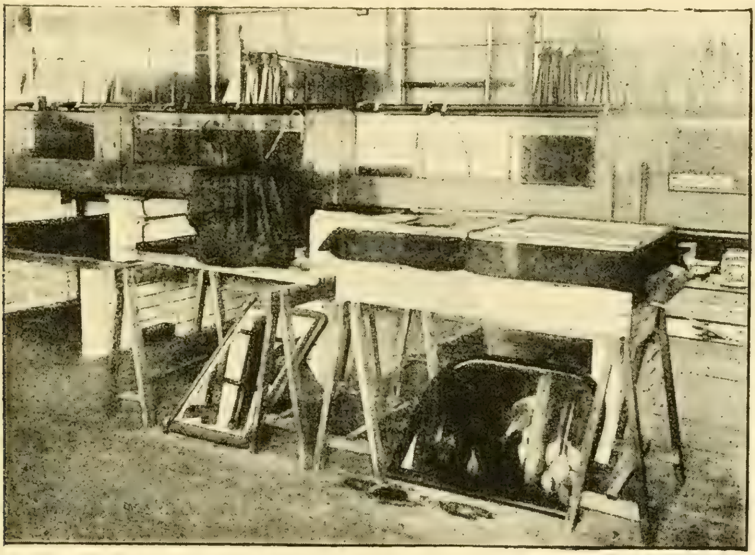
In another experiment I took one of this same brood (not one of the ninety just mentioned, but one taken before the examination referred to) which had one small spot of pigment close to the pectoral fin, and placed it in the apparatus, where its lower side was exposed to the light. In a few months the pigmentation of the lower side had extended over the greater part of that side.

Other similar experiments are described in greater detail in the full memoir by Dr. MacMunn and myself recently communicated to the Royal Society. Other experiments are now in progress, and a figure of the apparatus in use, prepared from a photograph, is here given. Besides the wooden tank already described and seen in the figure, there is also a large bell-jar. Both vessels are supported on trestles, and the large mirrors are placed beneath, upon the floor of the Laboratory. The vessels are placed in front of the tanks on the south side of the Laboratory and opposite the south windows, the supply of water being conveyed into the vessels by siphons from the Laboratory tanks. The fish are seen by reflection in the mirrors. At present the entrance of light is absolutely prevented by coverings of black cloth, or wooden covers lined with black cloth, except through the bottoms of the two vessels. The smaller fish are some reared from the brood of 1892, and the results exhibited by these are not yet published anywhere; the two larger fish are sole survivors from two separate experiments, and each of these is almost completely pigmented on the lower side.

During the period of time over which these experiments have extended, I have been studying, in collaboration with Dr. MacMunn, the anatomy and the physical and chemical properties of the elements to which the coloration is due. The results of these studies are fully described and illustrated in the memoir communicated to the Royal Society. A general account is all that can be given here. In the skins of flat-fishes the chromatophores have been described by Pouchet and other zoologists. They are of two kinds. Those of one kind are black or dark brown, have very definite outlines, and are contractile. They are stellate in form, having, when expanded, branching processes stretching out from the centre in all directions; but these processes can be partially or entirely retracted, and when completely contracted the chromatophore has a circular outline, being really nearly spherical in shape. The chromatophores of the other kind are yellow in colour. In the flounder the yellow deepens to orange at the centre. Usually the outlines of the coloured chromatophores are much less distinct and definite than those of the black, and it generally looks as though the pigment had diffused to some distance into the surrounding tissue. Nevertheless, contraction and dilatation of these yellow chromatophores takes place.

The chromatophores are of considerable size, easily seen with a low power of the microscope when a slice of the fresh skin is examined. But there are present much smaller elements which affect the coloration. These are angular plates of opaque substance of fixed form, having no colour, but reflecting light strongly. They are called iridocytes.

In the flounder, in the skin of the upper side a layer of chromatophores and iridocytes occurs close beneath the epidermis outside the scales, which are small and rudimentary. In the deeper part of the skin there are scarcely any chromatophores and no iridocytes, but on the inner surface of the skin there occurs another layer of chromatophores, black and yellow as in the superficial layer. Associated with the chromatophores here there are no iridocytes, but the place of the latter is taken by a continuous layer of opaque reflecting substance similar to that of which the iridocytes are composed. On the lower side of the fish chromatophores are entirely absent, but the iridocytes of the superficial layer are well developed. It is not these, however, which cause the opaque whiteness of the lower side of the flounder, for the layer containing these can be removed with a razor, and the whiteness of the skin remains. This characteristic of the lower skin is due to a thick, dense, continuous layer of reflecting substance on the inner surface of the skin, corresponding to the layer mentioned above in similar position on the upper side. This layer is much thicker on the lower side than on the upper.



The character and location of the elements of coloration are quite similar in other flat-fishes, but they are not always developed to the same degree. The chief variation is in the subcutaneous reflecting layer, which is in some species, *e. g.* the Megrim (*Arnoglossus megastoma*), almost entirely absent, represented only, whether on the upper or lower side, by separate small plates quite similar to iridocytes, but not so regularly arranged. In fact, comparative observations of different species, and the history of the development in the flounder, prove that the internal reflecting layer is actually derived from a layer of separate iridocytes which enlarge until they become continuous. This explains why the lower skin in the young flounder is not opaque white, but bluish and translucent. The chromatophores, both black and coloured, are the first elements of coloration to develop, appearing in the skin of the embryo even before it is hatched. The external iridocytes appear next, and are found in the flounder during its transformation when it is $\frac{1}{5}$ to $\frac{1}{4}$ of an inch in length. The internal reflecting layer of the lower side develops late and very gradually. It first appears in streaks along the lines of the intermuscular septa, when the flounder is about $1\frac{1}{2}$ inches long and extends gradually. When the flounder is 3 to 4 inches long, the white opacity is usually fully developed. The peritoneum contains the same elements of coloration as the skin, namely, chromatophores and reflecting substance, and it is an important and significant fact that in the normal flat-fish the chromatophores are present only in the peritoneum of the upper side, while in that of the lower side they are absent or very scarce, and on this side the reflecting tissue is more largely developed. In the flounder the reflecting substance appears in the peritoneum of the lower side earlier than in the skin, and as it is visible through the walls of the body the abdominal region in the young flounder is marked out as a white area, while the rest of the lower side is bluish and translucent.

As might be expected, the elements of coloration in other fishes are not essentially different from those of flat-fishes. But it is a striking peculiarity in the flat-fishes that they are destitute of the silveriness and iridescence which is so characteristic of many fishes, especially those like the mackerel and herring which are migratory or pelagic. Investigation shows that the silveriness of such fishes depends almost entirely on a thick subcutaneous or internal layer of reflecting substance corresponding to that of the flat-fish. These layers, in fact, are homologous, the difference in appearance being due to a difference in the structure of the reflecting layer, which in the flat-fish is granular, in the silvery fish is composed of minute parallel rods or needles. Both layers may be conveniently called the argenteum. In other fishes as in flat-fishes, chromatophores, black and coloured, occur in an external layer and an internal, and where the chromatophores are most developed the argenteum is evanescent, and *vice versâ*. In other fishes there are also bodies corresponding to iridocytes, but they vary in form and arrangement. In fishes whose skins are iridescent, as the herring, this quality is due to a layer of parallel rods or prisms of reflecting substance, which in the herring line the inner surface of each scale, or more accurately are present between those parts of the scales which overlap one another. The scales themselves are never iridescent. This iridescent substance is obtained from the scales of certain fishes, especially the fresh-water bleak (*Albunus lucidus*), and placed in the interior of thin glass beads to make artificial pearls. The coloured chromatophores of fishes are always of some shade of yellow or orange, deepening to red; in some the colour is a distinct red, as in the gurnards and red mullet. Green fishes occur, *e. g.* the green pipe-fish (*Siphonostoma typhle*) and the mackerel, but in such cases the colour is not due to green chromatophores. The coloured chromatophores in such fish are of a lemon-yellow colour by transmitted light, though it approximates to green when viewed at certain angles by reflected light. The green colour exhibited by the fish is due to the mixture of this yellow colour with the black of the black chromatophores, just as a mixture of gamboge and black among artists' pigments produces a green. No blue pigment either occurs in any fishes that I have examined, blue colours being due to the reflections of iridocytes, modified by black chromatophores.

As to the histological nature of these elements, it has generally been held that they are modified connective-tissue cells. This may be true of the chromatophores, but probably is not true of the iridocytes and reflecting tissue.

From a chemical point of view the reflecting substance is composed of a definite organic compound in an almost pure state, and the opacity and reflecting properties of the reflecting tissues or elements are those of this compound, varying according to the state of aggregation in which it exists. This substance, whose formula is $C_5H_5N_5O$, is connected with the uric acid series, but its chemical relations are not well understood. It is found in small quantities in the excretions of the excretory organs of certain Invertebrates, but has never been found associated with the kidneys of Vertebrates. It was first recognised as an abundant constituent of guano, derived in that substance from the skins of the fish devoured by the sea-birds, whose excrement formed the guano. The pigment of the black chromatophores is known as melanin, an organic compound which is extremely insoluble and indestructible, and, with slight variations, occurring almost universally in the animal kingdom. The pigments of the coloured chromatophores all belong to a well-characterised class of pigments known as lipochromes or fat-pigments, being of an oily nature, soluble in alcohol, ether, and other fat solvents, giving absorption bands in the spectroscope, and easily bleached under the action of light when removed from the living body.

To return finally to the effect of the action of light on the lower side of the flounder. Analysis shows that the result is a development of black and yellow chromatophores exactly similar to those of the upper side. At the same time there is a gradual diminution in the amount of the reflecting substance in the argenteum, while a change in the superficial iridocytes has not been observed. Whence do these chromatophores come? Do they migrate along the skin or through the tissues of the body from the skin of the upper side? or are they formed *in situ*, and, if so, how? We are not prepared at present to answer these questions definitely. We believe, however, that their presence is not due to migration, but that the pigment is formed from the elements supplied by the blood at or immediately near the place where they appear. That they do not come round the edge of the body along the tissues of the skin is proved by the fact that spots and patches of pigment may appear in any position, and quite isolated, on the lower side.

It is important to mention that, although chromatophores are present on both sides of the fish in the intermediate stages of metamorphosis at which most of these experiments have commenced, the action of light on the lower side never results in the retention of these chromatophores. The latter disappear from the lower side completely, and after prolonged action of the light they reappear. It is certain, therefore, that the disappearance of the pigment from the lower side in the normal flat-fish is an hereditary character, and not due to the withdrawal of the action of light in the individual. If the latter were the case, of course the pigment would be retained permanently from the larval stage as soon as the light was allowed permanently to act upon the lower side of the fish. The disappearance of the pigment is, therefore, an hereditary family character in the Pleuronectidæ. On the other hand, the fact that in these experiments the pigment, after prolonged action of the light, actually reappears is strong evidence (to my own mind a proof) that originally, in the beginning of the evolution, the pigment disappeared in consequence of the withdrawal of the lower sides from the action of light. If this be granted, it follows, of course, that a character originally acquired has become hereditary.

Pigment occurs as an occasional variation on the lower sides of flounders living free under natural conditions. That this does not invalidate the significance of these experiments is shown by the fact that in a number reared under normal conditions in the aquarium, only 1 in 90 showed a spot of pigment on the lower side, while of 94 specimens obtained from the estuary of Hamoaze only one showed a coloured spot on the lower side. Moreover, in the experiments the extent of the pigmentation, and the number of specimens exhibiting it, steadily increase from month to month, while in nature pigment on the lower sides is not any more common in large specimens than in small.

The above is a mere brief summary of general results and conclusions. The full description of the investigations, with illustrations, is contained only in the memoir communicated to the Royal Society.

NOTES AND MEMORANDA.

The Distribution of Unciola crenatipalma, Bate.—In my *Notes on the Marine Invertebrate Fauna of Plymouth for* 1892, in the last number of this Journal, I stated (p. 337) that although this interesting Amphipod is plentiful at Plymouth, its distribution seems to be very restricted, and that it is absent, among other catalogues, from my friend Mr. A. O. Walker's lists of the L. M. B. C. Amphipoda. Mr. Walker has, however, kindly called my attention to the fact that he has recorded the capture of several specimens of *Unciola irrorata,* Say, on the coast of Anglesey (Proc. Liv. Biol. Soc., iv, 1890, p. 243), and that he had little doubt that this name should really be *U. crenatipalma,* Bate. Upon comparison with some specimens of *U. crenatipalma* from Plymouth, Mr. Walker has been able to confirm the identity of the forms from the two localities, so that his record of *U. irrorata* in reality extends considerably the northern range of *U. crenatipalma.* The true *U. irrorata* of Say, he tells me, may be at once distinguished from *U. crenatipalma,* Bate, by the lower angles of the last two pleon segments, which in the former are produced into curved points, a distinction mentioned neither by Stebbing (Chall. Amphipoda) nor Bonnier (Bull. Sci. France, &c., 1889, t. xx, pp. 373—398). The known distribution of *U. crenatipalma,* from north to south, is now, therefore, as follows :—England : Anglesey (A. O. Walker) ; Weymouth (Gosse) ; Plymouth (Garstang). France : Dunkirk (de Guerne and Chevreux) ; Boulonnais (Bétencourt and Bonnier) ; Luc-sur-Mer, Belle-Ile and Croisic (Chevreux) ; Gulf of Gascony and north coast of Spain (Chevreux).—W. Garstang.

Raniceps raninus, Linn.—On the 23rd June, 1892, I received a specimen, $3\frac{1}{16}$ inches in length, which had been taken in a shove-net on the shore opposite New Clee Railway Station. No other examples were forthcoming until October, when, on the 25th and 26th, we took three on the Trinity, and four on the Middle Sand prawning ground in the shrimp-trawl. Of these, one measured $4\frac{1}{8}$ inches, and the others were about the same size. Two of them were placed in the Cleethorpes Aquarium, where they lived for some days, choosing, in the daytime, the darkest corner of the tank. One died, apparently from the effects of chafing ; and the other, which seemed healthy, contrived to get down the escape-pipe, and was killed. The resemblance borne by these lesser forkbeards to the dark variety of *Liparis Montagui,* which is the most common on the grounds where they were caught, is very striking when the fish are viewed from above. Even the dermal papillæ of Montagu's sucker are represented, though much less closely set, on the head of the gadvid.

Examples have been recorded from most of the British coasts, and the species has been taken in estuarine waters before, but I do not know that there is a distinct record of its occurrence at the extreme margin, as in the case of our first specimen. I imagine it must occur pretty regularly in the Humber, though I have found no one here who recollects to have met with it before. The resemblance to Montagu's sucker would probably account for its being overlooked by shrimp-trawlers.—E. W. L. H.

Chimæra monstrosa, Linn.—A male and a female of this species were taken in the second week of May by a Grimsby smack trawling from 70 into 135 fathoms, at the edge of the deep water to the north of the Great Fisher Bank, 320 miles from the Spurn. The abdominal viscera had been removed before they came under my observation. The male measures 27¼ inches in total length, the caudal filament being nearly perfect, whilst the pre-anal region measures 9½ inches. All the accessory sexual organs are well developed; it is the smallest mature male that I have seen. The female was about the same size.—E. W. L. H.

Lumpenus lampetræformis, Walbaum.—I have received a specimen taken, in company with another, by Mr. F. Klotz, s.s. "Dominican," at 23 to 25 fathoms, 240 miles E. ½ N. of the Spurn Light-vessel during the last week of July, 1892. The species was first added to the British list by the occurrence of an example on the east coast of Scotland (*vide* Day, Rep. S. F. B., 1884, p. 78), and has since been recorded by Dr. Günther from the west coast (P. R. S. E., vol. xv, 1888, p. 211). The locality from which mine was derived lies outside the British area, but I was under the impression that it was rather further south than any that had been recorded. Dr. Günther, however, informs me that he has seen a specimen said to have been taken on the coast of Norfolk.—E. W. L. H.

Gastrosteus pungitius, Linn.—The ten-spined stickleback is common in some brick-field ponds at Beaconthorpe, though not so numerous as the three-spined species. Both kinds have been used at the Cleethorpes Aquarium for some time for feeding anemones, especially *Urticina felina,* and I had never noticed that one species seemed less tolerant of sea-water than the other. I was therefore rather astonished to find an assertion, attributed, I suppose correctly, by Day to Couch, that *G. pungitius* "will not exist when confined in salt water, however diluted such may be." To test the truth of this, five examples were transferred from fresh to salt water. Three of them showed very little apparent irritation, but the two others gasped a good deal for some time, but finally, as far as the salinity of the water was concerned, the discomfort appeared to cease. These examples have failed, however, to adjust their air-bladders to the greater density of the salt water, and remained, in consequence, at the surface when at rest, though able to descend when inclined to do so. One has died, at the end of a week. Two appear perfectly contented with their new surroundings, and in no way inconvenienced by the density of the water, which is about 1·020°.—E. W. L. H.

Pleuronectes microcephalus, Donov.—I have alluded elsewhere to the occurrence of young lemon soles in the Humber in autumn. I have since received three, measuring 2¾, 4, and 5 inches respectively, which were taken on the Tetney ground on the 7th of April. It seems, therefore, probable that some of these fish remain in the river throughout the winter. Whilst reserving a more detailed description, it may be remarked that these small examples exhibit all the markings shown by the adult when taken on a bright-coloured ground. In both cases the markings disappear very rapidly after death, but the dark pigment can be fixed by alcohol.—E. W. L. H.

Scorpæna dactyloptera, De la Roche.—A specimen, 4¾ inches in total length, was taken in a shrimp-trawl on the Tetney ground on the night of the 17th April. It has the colours of the adult, but the lower rays of the pectoral fins are still connected by membrane, as in other young examples that have come under my notice.

The species is known to occur all along the European and North Atlantic slope, at depths between 54 and 527 fathoms, but there is no record of its occurrence on the English coast. As the Tetney ground is nowhere deeper than five fathoms, I would call attention to the extension of the vertical rather than to that of the horizontal range. From the accounts of prawn fishermen I believe that several other small examples have been taken in the Humber this spring. E. W. L. H.

North Sea Investigations.

(*Continued.*)

By

Ernest W. L. Holt,
Naturalist on Staff in Charge of Investigations.

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II. On the Iceland Trawl Fishery, with some Remarks on the History of the North Sea Trawling Grounds 129

I. On the Destruction of Immature Fish in the North Sea.

Introductory.—Owing to enforced idleness during the period which would otherwise have been devoted to preparing my reports for publication, I am under the necessity of reserving much of the information collected during the last four months for a future occasion, and of treating only in the briefest possible manner the few subjects selected for present discussion. I have again to express my obligations for much courtesy and assistance received from members of the Grimsby fishing community, and to the Marine Fisheries Society of the same town for cordial co-operation in the work carried on at their laboratory and aquarium at Cleethorpes.

The subjoined remarks are continued from those which appeared in the last number of this Journal, and the subject is treated in the same manner.

As I explained when endeavouring to compute the proportion to the total borne by the undersized fish recorded in the reports of last year, the method adopted by the Board of Trade statisticians in collecting their figures is not such as to inspire the most implicit confidence in the accuracy of their results. Accordingly, since during the present season more time was available for statistical investigations, I have relied for my totals on the method previously adopted only in the case of small fish, viz. on observations based on the number of boxes landed on the Grimsby pontoon. In this work

I have received the most valuable assistance from Mr. W. Clark, the laboratory attendant.

It is to be regretted that it was not possible to extend the statistics thus collected so as to comprise all members of the various species under discussion, but so little time elapses before the fish landed from the boats are sold and scattered that a considerable staff would be necessary for this purpose. I have therefore confined my efforts to obtaining an accurate account of all the plaice landed, since there is no doubt that, in view of the objects of these investigations, the plaice is the most important species. The haddock, no doubt, is equally or even more important in a general sense; but since it is a species which in no way lends itself to protection by means of a size limit, and which, on the whole, appears to have suffered less from over-fishing than any other, I have postponed for the present any attempt to collect full statistics. That my statistics are absolutely accurate is more than I can claim, but I believe that the method adopted presents less opportunities of error than any other feasible under existing circumstances. It will be noticed that in some months one or more days are omitted. I have purposely abstained from completing them by the deduction of an average, since the variation of the supply from day to day is so great that such an average is quite unreliable. In the case of large plaice, home consumption (by fishermen) is a not inconsiderable item. For this I have allowed, with, as I believe, approximate accuracy, by counting the level boxes landed from the only fleet fishing the grounds frequented by large fish as full boxes. So far as I know, no allowance is necessary in the case of the small plaice.

Plaice.—In my last report I enumerated the number of boxes containing only small fish landed up to the 20th March.

The figures for the whole month are as follows :

From the Eastern grounds . .	439 boxes.
From the Lincolnshire coast . .	40 „

During the following months the statistics deal with the whole quantity of fish landed. Boxes containing only small fish are recorded as "small," other boxes figuring as "large." Boxes from Iceland contain only large fish, and are enumerated separately.

Month.	Total boxes from N. Sea.	"Large" N. Sea.	"Small" N. Sea.	Iceland.
April	8,533	7,864	2,669	300
May, less one day . .	15,176	7,532	7,644	4,683 *
June	12,205	6,880	5,325	7,351
July, less one day . .	13,304	10,585	2,719	11,376
August, less four days . .	12,287	10,668	1,619	6,854

* This number includes all days on which fish were landed from Iceland.

In April 145, and in May 85 cases of small fish were sent to Grimsby market from the Continent by cargo boat.

Comparison with the figures for last year (N. S., vol. ii, p. 381) shows a very considerable increase in the quantity of "small" landed in the early part of the season, which commenced this year as early as March. This is due very largely to the early summer of the present year, which brought the fish, and, in their train, the boats, on to the eastern grounds sooner than usual. Moreover, instead of only sending one fleet to the Terschelling ground, during the present season Grimsby has furnished no less than four small fleets to assist in the work of destruction, whilst, in addition to steam trawlers hailing from our own and other British ports, we have been favoured with frequent visits from foreign vessels bringing small plaice from the same grounds. Thus in May 22 "voyages" of "small" were landed by British steam trawlers, whilst foreign vessels from Hamburg, Bremen, Gelstemünde, and Rostock contributed seven "voyages." The destruction was apportioned as follows :—by British steam trawlers, 3917 boxes; by foreign steam trawlers, 1642 boxes; by smacks, 2085 boxes. The latter were much hampered throughout the season by want of wind. Besides Grimsby boats, fleets from other east coast ports also visited the Terschelling and neighbouring grounds, including boats from Lowestoft. In view of the fact that our own boats brought practically none but small plaice from these grounds, it is somewhat surprising to learn from evidence given before the Parliamentary Committee that Lowestoft fishermen are so fortunate as never to catch any small fish at all.

Since the method of collecting statistics has during the present year been the same in the case of "large" and "small," we may venture to compute the comparative numbers of each with more accuracy than could be hoped for before. Taking the month of May as before, I found that 100 fish was the average contents of a box of "large," and that of these about 40 per cent. failed to reach what I consider to be the biological standard of maturity. There would therefore be in the boxes of "large" landed during May some 753,200 fish, of which 451,920 would be mature and 301,280 immature; whilst in the boxes of "small," containing each about 250 fish, practically the whole 1,911,000 fish would be immature. Thus of the total of 2,664,200 no less than 2,212,280 would be below the biological limit. This may be of some interest, but is of perhaps little practical importance, since, as I have endeavoured to show in former reports, we may hope to afford the necessary protection to the species without having recourse to the biological standard for legislative purposes. Indeed, from the experience of two seasons, I now believe that a limit of only 13 inches, but not an inch less, would serve the required purpose. Now in the boxes of "large" only about 7 per cent. are less than 13 inches in length, whilst in the boxes of "small" 10 per cent. is a very generous estimate of the proportion of fish above 13 inches. Hence we find that of the total given above 1,772,624 fish fail to reach the limit of 13 inches. Figures for every month might be computed on the same basis, allowing for some variation in the number of fish in a box of large. This depends largely on the grounds worked. In May, as it happened, no boats were at work on the Great Fisher Bank, where the proportion of large fish is the highest for the North Sea. During June and the following months a certain amount of trawling was done on that ground; later in the season the "Holman" catches would materially lessen the average number in a box, which would reach its minimum in the winter months, when comparatively few small plaice are brought ashore from any ground. It appeared to be a general idea amongst experienced men that the average number of fish in a box of large was about fifty, but I have been able to convince any who were willing to put the matter to the test that nowadays this estimate is far under the mark.

As to the Iceland fish, judged by North Sea standards, those from the open grounds are all large, and a box of 10 stone contains only some thirty fish. As those landed in May were all from such grounds the total number would be about 140,490. As the number of Iceland boxes during that month nearly equals a third of the North Sea total, the great difference of the total numbers of fish from each district is not uninstructive. From all accounts it appears to be much as though we were comparing the condition of the Dogger when first trawled with that to which we have now reduced it.

With regard to the "large" plaice landed, it may be mentioned with some satisfaction that the only Grimsby fleets which have during this year refrained from persecuting the small fish appear to have met with tolerable success. Of these the largest always lands its fish in London; and beyond that it was fishing the north-west corner of the Dogger during the summer I have no information as to its movements. The smaller fleet at first fished the same ground, and after refitting visited the "off grounds" of Scarborough, *i. e.* the ground lying about thirty-five miles off that port.

With regard to the Humber "flat-fish," they have this year formed an even more insignificant item in the market than was the case last year, and the District Fisheries Committee having now taken steps to enforce their bye-laws, it may be supposed that the appearance of small fish from our own territorial waters will in future years be extremely rare.

Probably the Humber plaice, which I found to be unusually abundant this summer, owed their comparative immunity in great part to the abundance of the prawns, which was such as to restrict the energies of the river trawlers to the legitimate objects of their industry. On the other hand, the general abundance of shrimps at the margin, by attracting unusual attention from the shore fishers, no doubt caused some increase in the destruction of very small plaice by the shove-nets and shrimp "seines." By substituting a cheese-cloth bag for that usually employed in the construction of a shove-net I succeeded in obtaining examples smaller than any which came under my notice last year. The first of these, measuring 15 mm., occurred on the 20th April, and probably represents the minimum size at which the species enters the river.

Turbot, brill, and soles.—On the whole the amount and proportion of small turbot landed during this season did not appear to differ greatly from the conditions recorded for last year. Amongst brill, however, I noticed that the proportion of immature fish landed from the eastern grounds was considerably higher than before, but still not such as to afford, from market observations alone, any evidence of very great destruction of the young of this species. A very marked improvement in the Terschelling sole fishery, attributed by fishermen to the warm summer, was the principal reason why so many of our smacks worked that ground during the present season; and it is to be regretted that the pursuit of this species entails so much destruction of small plaice, since the soles landed from Terschelling comprised only a small proportion of immature fish. Humber soles first made their appearance in the market on the 31st March; the fish, consisting, as last year, chiefly of immature specimens, remained abundant in the river throughout the season, but no very great catches were landed by the shrimp-trawlers. Very small examples, so far as I could ascertain, were taken by the shore shrimpers less frequently than last year; and on no occasion, when using the shove-net, did I catch any myself. The 8th August was the earliest date on which I obtained fish which appeared to be undoubtedly of this season's hatching. They were taken in a fine-mesh trawl, and measured $1\frac{3}{8}$ inches (35 mm. ca.) in total length, and others only slightly larger were taken during the few succeeding days. All other soles taken at the same time measured from 5 inches upwards.

Lemon soles.—No very large numbers of immature fish were observed in the market during the present year. From continuous observations of the catches of several shrimp-trawlers, who were kind enough to reserve for my examination all unmarketable fish obtained by them from time to time, I find that very small examples, such as those taken last year in the "Vallota," were present in the river from the beginning of April, and I have little doubt that some remain there throughout the whole year.

Haddock.—The appended figures show the total number of boxes of "small" landed during the months specified.

March, less six days	1,107 boxes.
April	2,424 "
May, less one day	2,890 "
June	3,596 "
July, less one day	3,841 "
August, less five days	5,761 "

Cod.—The appended figures relate to the boxes of small codling, as explained in the previous number of this Journal, landed by trawlers only, during the months specified.

March, less six days	2,037 boxes.
April	1,596 "
May, less one day	1,204 "
June, less one day	1,490 "
July, less one day	1,838 "
August, less five days	2,717 "

In the last number of this Journal I expressed the opinion that statistical inquiries would confirm the general belief that the amount of small haddock and codling landed by trawlers was less during the summer than during the winter months. The above figures, compared with those given for last winter, point, however, to the opposite conclusion, especially in the case of haddock, which show a steady increase throughout the summer. Codling, it is true, show a diminution between March and August, but it is only a slight one. However, since in the case of this species the summer supply of fish of all sizes was undoubtedly greater than that of the winter, it follows that the proportion of undersized fish was considerably larger during the latter period. This is very probably true also with regard to the haddock, but I have not the figures to show it. It is lamentable to reflect that whilst these wretched immature haddocks found a ready sale, at least double the quantity of large fish, of magnificent quality, had to be thrown overboard by Iceland trawlers as utterly unmarketable.

Whiting.—From examination of the catches of shrimp-trawlers, and from my own trawling operations in the Humber, I found that small whiting were very scarce in the river during the spring and summer, so that there was no possibility of any great destruction of the young of this species by river fishermen. I found some difficulty in obtaining sufficient numbers of small fish, even from deep-sea boats, to arrive at a conclusion as to the average size at which the fish reaches maturity. This appears to be about 9 inches, and fish of a less size are seldom brought to market. Considerable numbers are sometimes caught, but I have no doubt that a great proportion of immature whiting escape through the meshes of the ordinary deep-sea trawl.

II. On the Iceland Trawl Fishery, with some Remarks on the History of North Sea Trawling Grounds.

A result of the ever increasing scarcity of trawl fish in the North Sea has been that the more enterprising members of the fishing community are constantly seeking new grounds.

Thus in past years boats have been pushed out from Hull and Grimsby to the west of England, the west of Ireland, and during last year as far south as the Bay of Biscay; but though I am convinced that there is a great future for trawling on some of the off-shore grounds of the west of Ireland, I am not aware that up to the present time the results have been sufficiently remunerative to warrant any great influx of boats in any of the directions mentioned.

On the other hand, the boats which have pushed to the northward have been infinitely more successful. In this direction the line-fishers have always been the pioneers of the trade.

Thus the Great Fisher Bank, long known as a fine lining ground, was accidentally discovered to be suitable for trawling some twenty years ago, and it is only within about the last fourteen years that it seems to have been regularly trawled.

It has chiefly been fished in the winter, since it seems to be most productive at that season, whilst the east coast grounds have afforded occupation to the fleets in the summer.

Nowadays, however, the eastern grounds have so deteriorated, and public opinion has been so strongly directed against the destruction of undersized fish on these grounds, that the discovery of new grounds for the summer has been a matter of the highest importance.

The discovery of the splendid lining grounds (for halibut, &c.), commonly known as the Faroe "banks," was followed some years later by the opening up of the southern coasts of Iceland for similar operations, and for some years past Iceland has been the chief source of our supply of halibut during the summer months.

Trawling vessels which have been sent from time to time as far north as the Orkneys do not seem to have encountered much luck, though it appears that Scotch vessels have been more successful in this direction. Trawling has also been carried on, but as yet with only moderate success, to the east of the Shetlands, but the enterprise of one of our firms has at last opened up a trawling ground, the resources of which, if properly husbanded, can hardly be estimated.

In the summer of 1891 the s.s. "Aquarius" (Grimsby Steam Trawling Co., Mr. T. Cutton, master) shot a trawl off Ingol's Hofde Huk ("Ingol's Hoof" according to Grimsby pronunciation), on the south coast of Iceland, and returned with a fine catch of plaice and haddock. In the winter the Iceland grounds are closed, partly by ice, but more by the prevalence of foggy weather; but in the summer of 1892 about nine steam trawlers renewed the experiment.

Nature of Catch.

Large catches of plaice and haddock were made, the quantity varying from about 100 to 400 boxes of each per trip. Other items of the catch included witches (*P. cynoglossus*), common dabs, whiting, and Norway "haddock" (*Sebastes norvegicus*), all abundant; cod, ling, cat-fish (*A. lupus*), and skate, fairly plentiful; megrims (*Rh. megastoma*) common in certain parts of the ground; halibut moderately plentiful, but local. Lemon soles were very scarce, and no turbot, brill, or true soles were taken.

Of unmarketable species one specimen of *Molva abyssorum* and of *Gadus saida* respectively have reached my hands from Iceland trawlers. Long rough dabs and prickly rays (*R. radiata*) I have ascertained to be common, but my inquiries have failed to elicit evidence of the presence of any other species of food-fish.

Fishing Grounds.

The ground principally worked is known to our fishermen by the name of "Ingol's Hoof," and is described to me as lying off a fairly even stretch of coast which extends about S.W. from Ingol's Hofde Huk. The shore consists of low cliffs or banks, awash with the tide and pierced by the mouths of numerous streams draining the gradual incline of cindery volcanic soil which stretches seaward from a line of hills parallel to the shore. The bottom consists of very dark mud, the colour being due to its volcanic origin. Trawling is carried on at between 6 and 7 fathoms, close inshore, and about 40 fathoms in the offing, but a large part of the fishing took place in 1892, within three miles of the land. Another ground, more to the westward, is known as "Madam Piper's Bay," and trawling has also been carried on, with good results, off the West Horn at some distance off shore. In addition to these grounds, some of the fjords were also explored in 1892; and during the present year, in spite of a prohibition on the part of the Danish Government against fishing in territorial water, the practice has been continued by British boats. Several of these have had reason to regret it, having encountered rocks; whilst I am informed that one Danish steam trawler has become a total wreck. There can be no doubt, however, that there will be found ample room for the development of a large trawling industry without encroaching on the territorial waters; and we may here recall that when the Faroe banks were first found suitable for line-fishing, boats used to go there in twos and threes, it being supposed that the productive area was so limited that a single boat might miss it, whereas it has since proved to extend for hundreds of miles.

The plaice are very large as compared with North Sea fish, especially those from the Ingol's Hoof and West Horn grounds. The smallest fish I have ever seen brought in measured 12 inches; only an insignificant quantity were of less than 17 inches, whilst specimens of about 27 inches were a large item in the catch. The largest I measured was 30 inches long, but I am quite sure that I have seen specimens which were several inches longer. The maximum size recorded for North Sea fish is 28 inches. I have never seen any longer than 27 inches, and comparatively few above 24 inches.

The pigmentation is characteristic, and should serve to avoid the confusion that might otherwise arise in the minds of such naturalists as are apt to record anything they see on their fishmonger's stall as British. The ground colour, due to the darkness of the soil all along the coast, is a dark greyish brown, often very dark; the spots are usually much fewer than in North Sea fish, and often of very irregular outline; the central region is rust-colour, or a dark brown flecked with the former tint, and is surrounded by a broad and very distinct margin of a lighter shade, either white, cream-colour, or a brown much paler than the ground colour. In large examples this margin may measure from $\frac{1}{4}$ to $\frac{1}{2}$ an inch in width. In a few fish, however, in all cases small specimens, I have seen the spots as numerous, and of as bright an orange as one finds in Dogger fish, and I have reason to believe that the colour of the spots is not, as might be expected, dependent on that of the ground. This description applies, of course, only to dead fish, which would not show any mottlings that may exist in the ground colour during life.

In 1892 the fish were found in abundance at Ingol's Hoof from the beginning of June until the end of July, when a trawler who went there could find none. They seem, however, to have shortly returned. The other grounds were not worked in the beginning of the season, but yielded plenty of fish in July and August. After that the boats ceased to go there, and whether the fish remained on the grounds or not is unknown.

Haddock form an item no less important than the plaice. They appear to have been very abundant the whole time the trawlers were at work. They are of great size, the extreme length of those which I have measured in 1892 being 19 and 33 inches,* though no doubt both larger and smaller fish occurred. I should say that a North Sea haddock seldom attains a length exceeding 27 inches, whilst fish of only 10 inches are often thought worth bringing ashore. Without having submitted them to very minute comparison I can only say that the points in which Iceland differ from North Sea haddock appear to be only such as are dependent on the growth of the fish. They exhibit a very strong ridge in front of the first dorsal fin, and the lump in front of each eye is very prominent, but an approach to this condition is always apparent in the largest North Sea fish.

The witch (*P. cynoglossus*) is, I suppose, the next important species. On the whole I concluded that Iceland fish were rather smaller than their North Sea allies ; they are also much darker in colour, and would appear to extend into more shallow water.

Common dabs are, on the whole, considerably larger than North Sea fish, though I have occasionally noticed a specimen from the latter region as large as any from Iceland. In colour the northern representatives are a very dark sepia, devoid of spots or markings in the condition in which they reach this country. When long rough dabs have been brought in they have been of very large size, and similar in colour to the common dabs.

Not very many halibut were trawled at Ingol's Hoof, and such as were taken there were mostly of good size. On some other grounds, however, small fish, 14 inches and upwards, seemed rather abundant.

Megrim (*R. megastoma*) attain a very large size, but not, I should say, larger than in the Irish seas. I was told by the skipper of a trawler that they were chiefly caught in shallow water near fresh-water outlets. This is in marked contrast to the habitat of the species on our own coasts, but every student of ichthyology knows that the vertical distribution of a fish is often found to vary with the horizontal.

Whiting are very large, and, I believe, in good condition when caught, but as this fish requires to be very fresh to be valuable, it is not likely to form an important feature in the Iceland fishery.

Norway "haddock" (*Sebastes norvegicus*) appear to be very abundant, but in 1892 only those taken in the last few hauls were brought ashore, while in 1893 very few were landed at all. They ranged in size from 11 to 22 inches, the last being much the nearest to the average size. I was at pains to find out whether smaller specimens than those brought ashore were met with, but have only heard of one, which was brought to me, and measured about 7 inches. Day says the species attains a length of 4 feet, but no examples were met with by our trawlers larger than the size I have indicated. The colour is a reddish orange rather than scarlet, and the opercular spot is very faint. No transverse markings are apparent in the dead condition. They thus differ somewhat from the smaller specimens which are occasionally brought in from the neighbourhood of the Great Fisher Bank, and from the single small Iceland specimen. These agree in colour with the descriptions of *S. viviparus*, doubtless a synonym of the same species. As long as the Iceland fish continued to be brought in I found no marked change in the condition of the reproductive organs. The sperm-sacs in the male were charged with milt, and in the females the ovaries were small and flaccid, containing ova in various stages of development, but unripe, and a few larvæ, the bulk of the brood having apparently escaped.

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* The fish from Madam Piper's Bay are rather smaller than those from the other grounds.

Cod appeared to be in rather poor condition when landed, but this may have been as much due to want of space to pack them properly as from any other reason.

The skate which I examined corresponded for the most part with the descriptions of *Raia macrorhynchus*, but I was unable to satisfy myself that there were anything but varieties of *R. batis*. The same applies to all specimens of the larger species of *Raia* which I have seen brought in, whether by trawlers or liners, from the Iceland and Faroe grounds. Though there is infinite variety, so many intermediate forms occur that I have so far found no characters that denote the existence of more than one species. *R. alba* and *R. oxyrhynchus* are not represented, and I have not been able to detect *R. nidrosiensis* (Collett), if it has occurred.

Present Condition of the Industry.

It must be admitted that at present the Iceland trawl fishery has not been a great success from a pecuniary point of view, and it may be feared that if continued on the existing lines it may even deteriorate. The fishing grounds lie 900 miles from the mouth of the Humber, and the voyage thither consequently takes about 90 hours, ten knots being considered a very fair speed for a steam trawler to maintain during a long run. The utmost coal-carrying capacity of a boat, even when the fish hold is utilised as a bunker, and as much coal as the Board of Trade officials will permit is piled upon the deck, is for about three weeks' consumption. Consequently, the run to and fro occupying about a week and half a day, there remains at most only about a week for fishing operations. This, nevertheless, has been found quite enough to fill the ship, and indeed some vessels have landed large catches after only twelve days' absence. The Danish, and other continental steam trawling vessels, are rather larger than our own, and can therefore, I suppose, remain at sea for a longer period, but our fishermen consider that any advantages that may be gained by increasing the size of vessels are more than counterbalanced by the injury which a large vessel is apt to inflict on the trawl in a heavy swell. This distrust may ultimately be overcome, since we know that similar fears which manifested themselves at every increase in the tonnage of smacks have never been realised.

There have been two causes which account chiefly for the poorness of the pecuniary results of the Iceland venture—the great size of the plaice and haddock, and the poorness of quality of the former. This last character was especially noticeable in 1892. The spawning season off Iceland is much later than with us, many fish spawning as late as June. Consequently the plaice first landed last year were for the most part recently shotten, and they had hardly recovered condition to any appreciable extent before the season closed. Moreover they were only landed during the time when fish of all sorts were tolerably abundant, and had to contend in the market against great quantities of much smaller examples of their own species from the eastern grounds. It might be thought, after all the clamour that we have heard about the diminution in size and numbers of North Sea trawl-fish, that a good supply of large specimens would be welcome, but it is one of the most regrettable features in the trade (in view of the facility for obtaining legislation based on the size of fish landed), that very moderate sized or even small fish are in far greater demand than large ones.* Thus in 1892 the Iceland plaice could only fetch from 8*s.* 6*d.* to 11*s.* per box, though the boxes were piled so high that none could have contained less than 10 stone; as much or more could often be obtained for a box of small fish from the eastern grounds, and if the condition of the Iceland plaice left something to be desired, most assuredly that of the others was not much better.

Against the haddock nothing could be urged except that they were too big, the quality being undeniably splendid; yet in 1892 they were even less remunerative than the plaice. Boxes of 10 stone sold for eighteenpence or two shillings, and seldom brought as much as three shillings. Since I have been at Grimsby I have seldom known the smallest North Sea haddock fetch so little, though they are often none of the sweetest.

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* *Vide infra*, p. 139.

The "Norway haddock" also found a very poor market, but that is no more than could be expected in the case of a fish quite new to the consumer, and possessing, at least according to my own taste, but little intrinsic merit. They seem to me to resemble sea-bream more than anything else, but have less flavour and are drier. Still, being worth about 4*s.* a box, they paid the fisherman in 1892 better than the haddock, though it is probable that if brought ashore in larger numbers the market would soon have been glutted. In 1893, though as abundant as ever, very few indeed were brought ashore, in consequence, as I suppose, of the failure of an attempt to cure them during the previous year.

Taking advantage of the early summer of the present year, a start was made in April, the first boat landing its catch on the 14th. A very marked improvement was noticeable in the condition of the plaice, which were mostly fine firm fish, not yet ready to spawn, but as large as any that were brought in last year. The haddock were also in good condition, and as there was a good demand for fish, there was a ready sale. The plaice fetched 50*s.*, and the haddock 9*s.* per box. This seemed to promise better business for the Iceland boats, and it was not long before other "voyages" were landed, but the price was not maintained. Thus on the 2nd May plaice fetched only 17*s.* 9*d.*, and haddock 4*s.* per box, but witches found a ready sale at 27*s.* 6*d.* Prices remained about the same throughout the month, but in June we find plaice as low as 9*s.* 9*d.*, and never higher than 15*s.* The change is, of course, due in part to the greater abundance of fish in the market, and in part to the deterioration of the quality of the Iceland plaice, many of which were by that time shotten. Good prices were still obtainable for witches, but the haddock were driven out of the market, and it became the practice of fishermen to heave overboard all haddock except those caught in the last haul. Witches acquired an importance which they had not previously been suspected of, and the success of an Iceland voyage depended greatly on the quantity of that species landed. Cod continued to be brought ashore in considerable numbers, but, whatever their quality, the appearance of this fish after it has been some time in the fish-hold becomes unattractive, and I have known Iceland fish sell for only 8*s.* per score.

It is only natural that fishermen should have made endeavours to procure Iceland plaice more in accordance with market requirements than those with which I have been dealing, and in this they have been to some extent successful. I have seen several "voyages" of fish similar in size, and to a great extent in appearance, with ordinary

North Sea plaice; some of these were avowedly taken in fjords, where fishing by vessels other than Danish is illegal, and, though the fishermen observe a certain reticence on the subject, I have no doubt that all the small fish landed were caught close inshore. They commanded a ready sale at a remunerative price, but I am inclined to think that the prospects of the fishing are by no means improved by this circumstance. Though large enough by standard of North Sea fish to escape criticism, it is probable, taking into view the large size attained by the species in northern waters, that they are chiefly young and immature fish, the destruction of which is rather to be deplored, whilst any extensive poaching on Danish preserves in Iceland seems likely to hinder an understanding with that power which may become necessary with regard to other areas.

Comparison with North Sea Grounds.

The opening up a virgin trawling ground at a time when public (including scientific) attention is so much directed to fishery questions is of peculiar interest, since by watching its development we may be able to form a judgment as to the correctness of theories deduced from such accounts as we possess of the earlier history of the grounds off our own coasts.

These accounts are extremely meagre, consisting as they do of the reminiscences of a generation of fishermen which is now fast disappearing. Moreover to some minds they are prejudiced by the rather general idea that the conditions of the seafaring profession are not altogether unfavourable to the development of the imagination, and that the grain of salt proper to the assimilation of piscatorial narratives is not a small one.

Nevertheless there are certain facts which appear with remarkable regularity in all narratives, whether of those who actually witnessed the occurrences, or received them from their immediate predecessors. To take the Dogger Bank, which, as essentially a plaice and haddock ground, is well suited for comparison with the Iceland trawling grounds, I am given to understand on all hands that when the trawl was first used there an extraordinary number of large plaice were taken: they were not so large as the Iceland fish, nor in fact, so far as I can learn, any larger than some few which are still to be got in the same place; but the quality was very poor, and (Mr. G. Alward is my authority for this statement) the spots were brown and not red. Fishermen called them "elephants' lugs" in derision.

As trawling was continued a great improvement in quality was noticed, "shoal" fish becoming, as they have since remained, notable for their prime condition, and (again on Mr. Alward's authority) the improvement was accompanied by a change in the colour of the spots. It was some years before any scarcity of fish became noticeable, and when such scarcity induced fishermen to explore new grounds—*e. g.* the Brown Bank and some of the east coast grounds—the same phenomena were experienced so far as plaice were concerned.

There is thus a consensus of experience that trawling at first improves the quality of plaice, but that this process may be carried out with such hearty good-will that the fish incur the danger of being improved off the face of the earth, is an axiom which does not find such universal acceptance. Trawlers appear to consider that the action of their gear in stirring up the bottom and uncovering molluscs, worms, &c., is the principal cause of the improvement in plaice, but there is perhaps a more probable explanation.

The plaice is a fish which, after attaining a certain size, is little subject to the attacks of other species; in fact, I do not recollect ever to have found the remains of this fish in the stomach of any other, though I know that it occasionally falls a prey to the angler (*L. piscatorius*); nor can I find, by watching their habits in captivity, that plaice are much given to molesting each other. Consequently, on a ground which is never fished, it might well be that plaice would increase to such an extent that they would overtax the food supply, and, under such conditions, they would be of very poor quality. Seeing that the action of the trawl is infinitely more destructive to the plaice than to the organisms which form their food, trawling would at first, by thinning the numbers of the fish, increase the supply of food available for the survivors, and allow them to get into better condition than they were before. But as it is quite evident, if this theory is correct, that the quality is only raised at the expense of the quantity, it follows that unless this process is exercised in moderation the result must finally be disastrous. Nevertheless, in the face of universal experience to the contrary, there may yet be found those who assert that the more you trawl the more fish there will be.

As to the condition of the haddock in the early days of Dogger trawling I have no very definite information. They were very abundant, but I have not heard that they were of inferior quality, except on a ground lying to the east of the Dogger; there it appears that the objectionable smell of the viscera, due, no doubt, to the organisms on which they fed, was the worst fault that could be urged against them. The truth is that haddock were so utterly worthless to trawlers until a curing establishment was started at

Hull some time in the forties, that little or no attention was paid to them; they were amongst the perquisites of the apprentices, and this circumstance may have prevented them from being thrown overboard in very great numbers, but certainly many of them must have been treated in this way. I have endeavoured to show in the last number of this Journal that it is of little use returning trawled haddock to the sea, and there can be no doubt but that the shovelling overboard of large quantities of dead fish is injurious to a fishing ground. We may suspect, indeed, that this practice, which was extensively carried out in the case of small plaice, on some, at any rate, of the North Sea grounds, may have had its share in the diminution of the general fish supply, and it is matter for the greatest regret that it has been commenced, in the case of large haddock, on the Iceland grounds. It is hardly to be supposed that much effect would be felt as yet, but it is a fact that the liners can no longer get their fish on the grounds where the trawlers have been at work this season, and I am inclined to think that they, the liners, are right in attributing this circumstance as much to the fouling of the bottom with great quantities of dead haddock as to the disturbance caused by the trawl. As I have said, no improvement is possible in the condition of the haddock, and we must look to market considerations only to check the present waste of large specimens; but in the case of plaice I think we may reasonably hope that a slight diminution by trawling may effect an improvement in condition, and should this be attained, and the grounds be not unduly fouled, the climatic conditions of the locality not less than its distance from the markets may probably, by providing a most efficient close season, suffice to avert for many years the final and disastrous stage arising from over-fishing.

Alleged Cause of Low Prices.

A few words as to the apparent causes of the low price of Iceland fish may not be out of place. I have made inquiries amongst members of the buying fraternity most interested in the matter, but I fear the relations of supply and demand in fish are beyond the comprehension of the lay mind, and can only give the facts as they are told to me, with such comments as may occur.

The Iceland plaice are too large to be sold fresh, and have therefore been mostly drysalted and sent to Holland and Germany, but they are difficult to cure, being very watery, and do not sell well.

Granting the present poorness of quality, which we may hope to see disappear as the fishery develops, I do not understand why it should be ncessary to cure and export them. If the demand for cheap fresh fish in our own country is a genuine one, it is surely possible to place these fish, which only cost the buyer something less than a shilling a stone, before the consumer at a price at which the latter would not complain, and which would yet leave to the former, and also to the fishmonger, a decent margin of profit. There seems no difficulty in disposing of undersized fish, of which the quality is certainly not better.

As to the haddock, I am informed that they are too large for smoking, for this reason,—that it is impossible to place a smoked haddock of that size on the market for less than sixpence (though it may be remarked that it only cost the curer about a penny when fresh); and that the consumer, who for the most part belongs to the poorer classes, has usually only a penny or twopence to spend, for which sum he can obtain a small cured haddock. The retailers will not cut up the fish, because it spoils the appearance *and lowers the price.* I am told that most of the Iceland haddock brought here in 1892 were split, drysalted, and exported, but that the profits were infinitesimal.

In the fresh condition, available, as they were in 1892 and will probably be in most future years, only in the summer, Iceland haddock have to contend in the market with the immense supply of herrings prevalent during that season. There is no doubt that they would sell splendidly in the winter, and even later in the autumn I am told there would be a good market for them in Rotterdam. Line-caught fish suffer from the same competition, and I have seen 285 from 21 to 30 inches in length sold on the 13th September for twenty-five shillings, the seller informing me that he could confidently reckon on getting a shilling each for such fish a month later. For myself I cannot but think that they could be placed on the market in the fresh condition at a price at which they might compete favorably with the herring; and the only conclusion I can form on the whole matter is that the producer and consumer would find it to their mutual advantage to be brought into closer relationships.

Though not to any great extent a product of the trawl fishery, there is another northern species to which I would like to advert here briefly, viz. the tusk (*Brosmius brosme*). Great numbers of tusk are caught by our liners on the Faroe grounds all the year round, and on the Iceland grounds during the time they are worked,* but the fish are seldom brought ashore except in the winter, as that is the only time when they command a sufficiently high price to make it worth the fisherman's while. Nevertheless the tusk experiences no immunity in the summer, being the unfortunate possessor of a very large liver, which goes to fill the liver cask.* There is thus a most regrettable waste of good food.

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* I am told that in these latitudes tusk come into quite shallow water.

Dr. Günther originally directed my attention to the impossibility of procuring this fish, which he, with reason, considers one of the best that swims, in London, and I find, on inquiry, that they can only be sold either to workhouses and such institutions, or to fish-hawkers who take them into the country and dispose of them under the name of "Deep-sea Ling." This vernacular name is at least as apt as that by which they are known to naturalists and fishermen in this country, torsk or tusk being etymologically identical with Celtic, German, and Scandinavian names applied to the cod and some of its congeners.

If the merits of this fish as an article of food were more widely recognised it could not but be beneficial to the industry, and would do away with the almost wanton waste that now takes place in the summer, whilst the advantage to the consumer would be commensurate.

In this connection it may be interesting to glance at the fate of certain other fishes after they reach the market. Every one knows that the parts of the skate which appear at table are the wings or pectoral fins, but it may not be so generally known that the removal and preparations of these wings is a separate though small industry, and that the only consideration received by those engaged in it is the refuse of the skate, viz. the head, abdomen, pelvic fins, and tail. Nevertheless the business is said to be a paying one. After the wings have been removed there remain certain lumps of flesh on the carcass, those of most account being the masseter muscles. These are carefully removed and disposed of to fried-fish shops as "skates' nobs," a delicacy much in favour with the patrons of such establishments, and reputed to possess the peculiar virtue ascribed to skate's flesh in its greatest degree. I believe, however, I am betraying no secret in remarking that there may be ingredients in the preparation which are not mentioned in its title. Cat-fish (*Anarrhichas lupus* and *A. minor*) are prepared for transmission to the fishmonger by removing the skin and head, and in this instance again the refuse is the recompense of the operator, who cuts out the very large cheek muscles. The tail of the monk or angler (*Lophius piscatorius*) when skinned and cut up into lumps is not unlike the flesh of the skate; at all events, like the fragments of Anarrhichas, it is used to adulterate "skates' nobs," and I do not know that the latter are considered any the worse for it.

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* The livers and roes of fish are about the only remnants of the old "stocker-bait," the perquisite of the inferior members of the crew. It may not be generally known that haddocks were once included in this term. Livers fetch about 10*s*. and roes about 6*s*. per cask. The former are not infrequently adulterated with *Actinoloba dianthus!*

Coal-fish (*Gadus virens*), whether from liners or trawlers, are common enough in Grimsby market, and the trawlers often bring in a few large pollack (*G. pollachius*), the largest I have measured being forty-three inches in total length. Both of these species are extensively bought by country hawkers, who scrape off the scales, and find a ready sale for them under the title of "white salmon."

Conclusions.

To return to matters more essentially germane to the subject under discussion in these remarks, I would submit that the present condition of the Iceland trawl-fishery forms no insignificant argument for preventing the destruction of undersized fish. I think it will be admitted that if the market could once be cleared of the immense quantities of small plaice which flood it during the summer months an improvement of price for full-grown fish, by no means confined to that species, would be one of the first results; at the same time the large quantities of haddock, torsk, &c., which are at present wasted, would, by becoming moderately profitable to the fisherman, serve to supply the market sufficiently to prevent any undue strain on the purse of the consumer; at the same time the present practice of fouling the Iceland grounds with dead fish would be checked, to their incalculable benefit. It matters little by what means the sale of small plaice is prevented so long as it is done effectually; and though I see no reason to alter my opinion that the enforcement of a reasonable size-limit for flat-fish is the most feasible plan, I am quite prepared to bow to the superior wisdom of those in favour of geographical restrictions, whenever, by such means, their object shall have been attained.

I have before this endeavoured to show that the size-limit for plaice which I have recommended would have the same result as the geographical restrictions generally desired in closing the eastern grounds of the North Sea to trawlers; and if this object is attained, by whatever means, it becomes apparent that we must look for an outlet for our boats during the summer months. Such, in my opinion, is offered by the Iceland grounds, and, as we have seen, the steam trawlers have largely availed themselves of it. It cannot be denied, however, that smacks working there would be liable to risks which at present are more or less prohibitive. It is a dangerous coast, apparently not too well charted, subject to fogs, and hardly lighted at all. It is a great distance from our ports, and it is absolutely impossible for a vessel which may be disabled there to refit without sending for supplies from home. It appears, therefore, that whilst single boating would be out of the question, smack-owners could hardly think of sending their fleets there without establishing depôts on the island and arranging for some improvement in the lighting during the fishing season. The establishment of depôts would of course bring profit to the inhabitants, and for this consideration the Government of the latter might perhaps be induced to undertake the duties of lighting and of improving the present harbour accommodation, which is, I understand, of the scantiest. I make these suggestions with all due deference, since those engaged in the North Sea fishing trade are about the last persons to be accused of a want of enterprise or of incapability of safe-guarding their own interests; but I have no doubt that the check on the fish supply of the North Sea, which, until the beneficial action of such has time to make itself felt, must ensue from legislative action, or, in the absence of that, the continued depletion of the grounds, will before long result in the establishment of Iceland fleeting during the summer.

Letter from Wilfrid T. Grenfell, Esq., M.R.C.S.,

Superintendent of the Mission to Deep Sea Fishermen.

At the request of the Secretary I venture to send you a brief account of the voyage we made last year in the smack "Albert" 97 tons register, belonging to the Council of the Mission to Deep Sea Fishermen.

We sailed from Yarmouth on June 15th and returned on December 1st, having sailed to St. John's in Newfoundland, along the coast to Labrador and as far north as Hopedale, thence south again and up the Straits of Belle Isle, visiting almost all the fishing stations, and returning by St. John's direct to Yarmouth. The return journey from St. John's to the Start Lighthouse was accomplished in only twelve days.

Your Society, through the Director of the Plymouth Laboratory, furnished me with three deep-sea reversing thermometers, and one instrument for bringing up specimens of bottom water. We used the thermometers on wire with Basnett's patent deep-sea sounder, but this was only gauged up to 100 fathoms, and, not having any line suitable for the thermometers on board, I was unable to take any very deep soundings. Moreover, the work was new to me, and until I was joined by Mr. Adolph Nielsen, the Superintendent of Fisheries for Newfoundland, I had, I am sorry to confess, not realised the value which soundings might have. In the Report of the Fishery Commission of the colony the scientific work carried out is fully detailed, and for those who have not access to that little book it may be worth while my summarising the general conclusions arrived at, especially as to the results to be anticipated from a more extended series of observations, and as to the lines on which these should be made.

We added to that work surface temperatures across the Atlantic both ways, and on our return journey were only prevented by extremely boisterous weather from recording deep-sea soundings also. The observations I have forwarded to the Plymouth Laboratory. Captain Sir Baldwin Walker, R.N., has since shown me some interesting records he made during four years on the Newfoundland coast in H.M.S. "Emerald," but he regrets greatly that the Naval officers along these shores have no reversing thermometers for deep-sea work. Without any doubt repeated observations made all round the coast would become of the highest value.

The very life of the colony is at times imperilled by the critical condition of the fisheries,—lobsters failing, seals not being found, herring not reaching the coast, and cod vacating their normal haunts. Poverty, misery, and want, with great loss to merchants as well as fisher-folk, result, a great deal of which might apparently be avoided if more were known about the movements of the fish, of the bait, and of the Arctic and Gulf currents, which seem constantly to be varying, and may account often for most unexpected failures.

The resident English fisher-folk along the coast number some 5000, while every summer about 25,000 to 30,000 men, women, and children flock from Newfoundland to catch cod on the Labrador coast. They remain from three to four months, returning only when compelled by the sea freezing over.

I must be categorical in my description of these people in order to convey succinctly an idea of this peculiar fishery.

The coast is rugged and broken, the country barren and inhospitable. Eight months in the year both sea and land are completely ice-bound. No domestic animals but dogs exist, and no vegetables can be grown, except a chance potato or cabbage in the very extreme south.

The people have *no legal representative whatever*, though a Custom-house official visits the coast in the summer in a small schooner, and is also empowered to act as a magistrate. If a criminal wishes to be tried he could with some difficulty manage it.

The schooners which bring the people form a very assorted fleet, and carry a mixed crew of men and women, besides more or fewer passengers who have no boats of their own to come in. These latter huddle into the main hold on the top of the salt, fishing gear, and stores. These boats are not surveyed before starting, and do not all clear from any custom house. More surveyors and better arrangements are urgently necessary.

Once on the coast, mud huts and small stages are erected, the merchants' agent or a large fish planter generally having a larger stage, and a store of goods near the people he has "supplied."

A universal truck system exists, and at the end of the summer the dry fish are "weighed in" in quintals (hundredweights), and go to pay off the outfit advanced in spring. The fish are caught on "jiggers," two hooks back-to-back, or in cod traps, which are simply submerged rooms of nets; but squid, caplin, or launce are used for bait when obtainable.

The cod is successively "throated," "headed," "split," "salted," and dried in the sun, and then sent to Mediterranean, English, or Brazilian markets.

The people are a fine, tall, well-built race, brave to fool-hardiness, and generous and hospitable to a fault. Accidents and sickness are by no means uncommon; I have always found the people dividing up orphaned children among themselves, and even Esquimaux rearing the orphans of English settlers.

They experienced this year epidemics of diphtheria and influenza, the people dying in many parts without any possibility of getting medical assistance. No doctor resides anywhere on the coast.

Their hospitality to one another in the winter, when all the country is cut off from the civilised world, brings them occasionally to the verge of starvation.

The causes leading to the summer migration are :—(1) The decline of the Bank Fishery and the French and Canadian bounties; (2) the depletion of the inshore cod and lobster fisheries; (3) the monopoly of the winter seal fishery by the large steamers of the merchants' firms; (4) the crippling of any development of agriculture or mining by the French treaty rights on the shore. It is interesting to note that not more than 500 Frenchmen find it worth their while to fish in summer on the Newfoundland coast, and yet to preserve that exclusive right the only possible resource, in the case of the failure of the fisheries, is entirely destroyed in this, our oldest British colony.

The following is a summary from Mr. Nielsen's report. First of all, he shows from his Norwegian experiences that codfish do seek waters of a certain temperature; (2) that these temperatures can be ascertained; (3) that by the use of deep-sea thermometers more successful fishing can be ensured than by haphazard work; (4) that the fishermen in the Lofoden Islands have used these instruments with great success; (5) that codfish in different countries learn to endure different temperatures within certain limits; (6) that cod thrive between 34° and 52° F., that outside these limits they get drowsy and stop feeding, but do not necessarily lose in condition or flesh; (7) that cod quickly perish from cold when the temperature sinks below 31° F. Moreover fishermen on the coast said that they could have filled their nets and vessels with codfish in this stunned condition at some places off the Labrador coast if they had had a cod seine, and at the same time they lost their summer's "fare" of fish, because the cod would not feed. At times in the stomach of these fish lumps of ice are found, probably frozen after death. Mr. Nielsen sums up as follows :—"The meteorological condition of the waters has a most effective influence upon the habits and movements of the fish and bait, and is a very important factor to take into consideration in the prosecution of the fisheries on the coast of Labrador. I feel certain, therefore, that the use of deep-sea thermometers in the Labrador fisheries would be of the greatest advantage to all interested in this industry in finding and locating the fish after the fishermen once learned how and where to use them, and by experience had obtained the required judgment and knowledge of the habits and movements of the cod in waters of various temperatures in the different localities on the coast."

Indeed Mr. Nielsen eventually proved most successful as a piscatorial prophet, and could tell the fishermen who took us around on the banks where to fish with most success. He based his prophecies on the fact that uneven bottoms with lively vegetation and a rotatory current, where the temperature ranged between 36° and 39° F., and the specific gravity between 1·026 and 1·027, were the best.

The water off the coast never exceeds 46½° F., even on the hottest summer day, and in some places we found layers of hot in cold water, varying at different depths, or again at short distances apart.

Thus in one place at the bottom (110 fathoms) the temperature was 31·7°, at 100 fathoms 36°, at 80 fathoms 31°, till at 15 fathoms it again became warmer. Thus the fish would be stunned from 15 fathoms, and would feed and live at 100 fathoms down.

What is the source of the hot water? Is it from (1) hot springs, from (2) uncharted branches of the Gulf stream, from (3) unknown far-north warm sources, or from (4) land-water as rivers? Whatever is the source the great rush of thousands of fisherfolk to be first in following up the retreating ice of winter is sufficient to prove that cod are found far north, where we are apt to think no fish could exist, and that as they get further north the fishermen have of late years found the cod more abundant. It is thought on the coast that not only the cod but also the herring, which have been disappearing from southern Labrador of late years, are working further and further into Arctic regions. There seems little reason to doubt at any rate that the movements of the herring and caplin, which are the food of the cod, are largely influenced by meteorological conditions, as well as the other food on which in turn these fishes feed. It was remarkable that at Okak this year the vessels fishing were almost "clean," getting no fish at all, while both north and south of that station good catches were made. Perhaps had they had thermometers they could have foretold this result and saved their voyage. Possibly a temporary inset of some cold current from a change in the formation of the bottom would account for this.

In the Arctic current we found numbers of specimens of animal life, and under stones and in small pools on the shore there were abundant evidences of organic life. Our preparation, however, both for collecting and storing had been very insufficient, and not much was done in collecting with surface nets or dredges. We sail again about May the 30th from the west coast of England, but we shall again be greatly hampered on so broken and so badly charted a coast, as the necessary funds have not come to hand to allow of the purchase of a small steam launch to tend the vessel.

W. T. Grenfell.

Council of the Marine Biological Association.

Note.—Mr. Grenfell, who made surface collections for the Association some time since (Journ. Mar. Biol. Ass., Vol. I, p. 376), and was supplied by us with deep-sea thermometers for his last voyage, left England again in May for Newfoundland and Labrador, taking with him apparatus for a more elaborate scheme of work; it is hoped that his observations will throw further light on the movements and habits of the cod as affected by their food, &c. For such observations no better locality could be selected than the Newfoundland banks.—G. H. F.

The Life-history of the Pilchard.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

We have recently begun to receive from the French Ministère de la Marine a monthly journal entitled Pêches Maritimes, and published as a supplement to the Revue Maritime et Coloniale. The number for August of this journal commences with an article on *La biologie de la sardine,* by M. Paul Guéry. This article consists chiefly of summaries of the researches of four zoologists on the reproduction and life-history of the sardine. We have the summaries given under the following headings :

1. Le laboratoire de Concarneau. Opinion de M. le Professeur Pouchet.
2. Le laboratoire d'Endoume. Opinion de M. le Professeur Marion.
3. Laboratoire de Plymouth. Opinion de M. Cunningham.
4. Opinion de M. le Dr. Henneguy.

In the first section it is stated that in Professor Pouchet's opinion the sardine is a fish of the high seas, attracted to the coast neither by hunger nor the reproductive instinct, but whose migrations are determined by the wandering instinct characteristic of pelagic species, and are subject at most only to influences of temperature. It is pointed out that, according to M. Pouchet, we know nothing concerning the life-history of the sardine.

Then Prof. Marion's conclusions concerning the Mediterranean sardine are described with this difference, that, whereas no observations made by Prof. Pouchet are mentioned, some account is given of the observations of Prof. Marion on which his conclusions are founded. It cannot be said that full justice is done to these observations, no mention being made of the eggs found in the sea, and identified by Prof. Marion as those of the sardine, but we must make allowance for the restrictions of space.

No objection can be taken to the summary given of my own observations, as published previously in our Journal, except that after they have been correctly quoted they are called *theories* which differ from those of Concarneau. M. Henneguy has studied the question whether any relation could be discovered between the varying abundance of sardines and variations in the abundance of any pelagic organisms which form their principal food. His results were negative.

The commentary by the writer of the article upon the publications which he has summarised is remarkable and surprising. He says the contradiction between the results reached on the one hand at Concarneau and on the other at Plymouth and Endoume is a matter for anxiety as to the reality of the progress made. One is obliged, he says, to accord the same degree of confidence to the statement of men who devote to the service of truth the same zeal, the same loyalty, and the same knowledge. And yet they contradict each other, and the conclusion drawn is that laboratory work is not adapted to solve the problem of the biology of the sardine. This, it seems to me, exemplifies the erroneous way in which scientific evidence is usually regarded by practical men, whether on boards of authority, commissions of inquiry, or in courts of justice. The opinion of one expert is weighed against that of another, and the only comparison by which they are judged is the reputation and authority of their respective authors. Therefore if two experts of equal reputation give contradictory opinions the result is zero. Now it is perfectly obvious that the reputation of a man should depend on the truth of his conclusions and not *vice versâ*, and that in a question of evidence the reputation of the witness is of no importance if he has no evidence to give. But the difficulty is that in the experience of men of affairs scientific methods and scientific knowledge are so completely excluded that they cannot give due weight to the facts on which opinions are based, and cannot therefore judge whether one opinion has more foundation than another. In the question of the reproduction of the sardine, which to anyone familiar with researches on the life-history of fishes is not so wonderfully complicated, the fact that Prof. Pouchet has not seen the ripe eggs of the fish, or the ripe fish themselves, does not in the least invalidate the observations of those who have seen them, namely, Prof. Marion and myself.

However, I have recently been able to add to the observations I have previously made on the reproduction and development of the pilchard. This year I have for the first time obtained artificially-fertilised eggs, and hatched the larvæ in the laboratory, and succeeded in rearing the larvæ for several days after hatching.

The eggs were taken from ripe fish obtained on the night of

September 5th, ten miles south of the Eddystone, by the crew of a Plymouth boat, to whom I had given bottles for carrying the eggs and instructions for dealing with them. Usually ripe pilchards are caught in mackerel nets, pilchard nets not being often used at a sufficient distance from land during the season when pilchards spawn, but in this case the boat was using pilchard nets and fishing for pilchards. The total catch amounted to 2,200 fish, but only a few of those were ripe. In the bottles when brought to me there were a considerable number of dead eggs at the bottom, but several thousands of living ones floating at the surface of the water. These were fertilised and developing, the blastoderm having extended already half round the yolk.

The characteristics of the eggs I have described in previous papers. In these, the divided yolk, single oil-globule, and large perivitelline space were present exactly as in the eggs obtained from the sea, or the unfertilised eggs taken on previous occasions from the fish. A drawing of one of these eggs actually taken from the pilchard and artificially fertilised, agrees in all respects with the figure which I published as the egg of the pilchard in Plate 5 of Vol. I of this Journal. But among these eggs I noticed one which presented an interesting variation or abnormality. This egg is represented in Fig. 1. It resembled the other eggs in all respects except one, namely, that instead of the normal large space between the envelope or vitelline membrane and the egg proper, there was a narrow space as in the majority of other pelagic eggs, for instance the mackerel or plaice. I once found an egg showing this character among those taken from the sea by the tow-net, and thought it was the egg of some other species, its parentage being unknown. It is now clear that it represents an occasional variation in the egg of the pilchard. I kept this egg separate until it was hatched, and found the larva

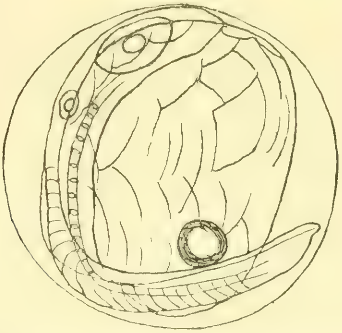

FIG. 1.—Abnormal, but healthy, egg of the pilchard, having small perivitelline space.

hatched from it differed in no respect from those hatched from normal eggs.

These pilchard eggs were placed in a glass hatching jar in one of the laboratory tanks, and treated in the way described in my Treatise on the Sole. The temperature of the water was 17° C., and its density, 1026·5. The eggs all hatched on September 7th, only three days after fertilization. The newly-hatched larvæ agreed exactly with Fig. 30, plate 5 of Vol. I of this Journal. The larva is 3·8 mm. in length. Fig. 2 shows the appearance of the living larva seen from above in its natural position, floating with the yolk-sac uppermost. In this position little protuberances are seen on each side of the body; these are larval sense organs, such as are seen in the larvæ of fishes generally, and from them are derived the sense organs of the lateral line, but in the adult pilchard these sense organs are wanting, so that the larval sense organs evidently disappear during development.

When the larva is first hatched the yolk is large, the mouth not open, and there is no pigment, except a few black chromatophores along the dorsal region of the body. The yolk diminished on the second day, September 8th, and on the third day, September 9th, the mouth was found to be open as a wide rhomboidal aperture on the under surface of the head. A little yellow pigment and reflecting substance was now present in the eye.

On the 10th, by the growth of the lower jaw and under parts of the head, the mouth had become terminal; the eyes were black and opaque, and there were black chromatophores along the sides of the body ventrally. The yolk was reduced to a very small remnant, and with the absorption of the yolk the head region had become much shorter in comparison with the rest of the body. On this day I tried to feed the larvæ with minute particles obtained from minced worms, but they took none of it.

On the 11th I gave them some of the minute organisms obtained by the tow-net, and also a little more of the worm food, and, on examining some of the larvæ, saw some of the food in the intestine. The food was particles of worm.

On the 12th, when the larvæ were five days old, they were 5·5 mm. in length, the yolk was all gone, and they continued to feed on the particles of worm. Although I had the finest tow-net used, and put the produce into the jar containing the larvæ, none of it was ever found in their intestines. The tow-net produce included minute Peridiniidæ, diatoms, worm larvæ, &c., which I thought probably formed the natural food of the larvæ, but they did not feed on it. On the 14th there was evidently a diminution in the number of the larvæ, and I found that some had died and fallen to the bottom of the jar. During

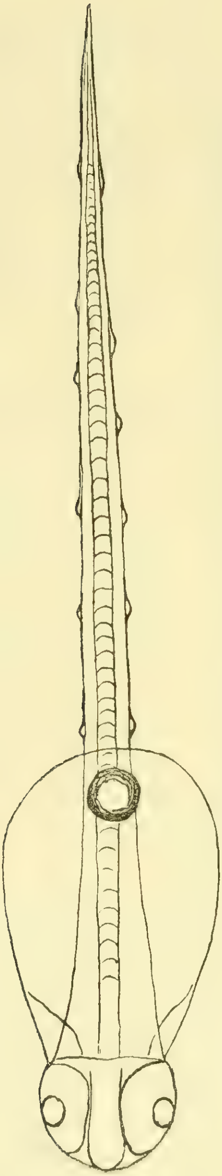

FIG. 2.—Newly-hatched larva of the pilchard, with ventral surface uppermost, showing sensory papillæ.

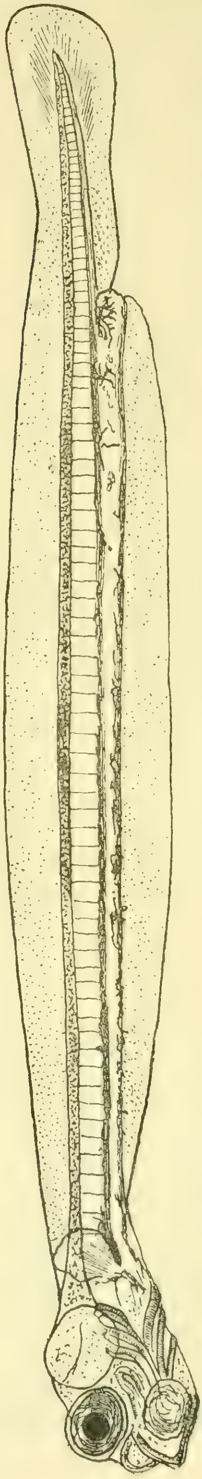

FIG. 3.—Larva of pilchard, nine days old.

the days that they were feeding they were seen to "peck" at the particles of food suspended in the water, and the food was seen in the intestine as a white opaque mass contrasting with the transparency of the body. On the 15th there were few left alive, and on the 17th only one was left, which I took out and mounted. Thus, the longest time any were kept alive was ten days. In the oldest larvæ no great advance in development had taken place ; no indication of the permanent fin-rays had appeared, but radiating lines in the larval fin in the caudal region indicated the commencement of the primitive fin-rays. The oldest larvæ did not exceed 5·5 mm. in length in the preserved condition, and very little shrinkage took place in the process of preservation. Fig. 3 shows the condition of one of the larva killed and preserved on September 16th, when nine days old.

In September I found that the Saltash men were fishing with large seines for sprats, in the Hamoaze on the west shore, between St. John's Lake and Millbrook Lake. Besides abundance of adult sprats there were taken numbers of small fish of the character of whitebait, and miscellaneous fish of other kinds, including a few small mackerel, small bream, and *Belone acus*. On examining a sample of the small clupeoids I found they consisted chiefly of young sprats from $2\frac{1}{8}$ to $3\frac{1}{2}$ inches in length, evidently the produce of the preceding spawning season in the early part of the year. But there was also a small proportion of young pilchards, $2\frac{3}{4}$ to $4\frac{5}{8}$ inches in length. These must be derived from the spawn shed in the same year in the early part of the spawning period, that is to say in the months of May and June. It has long been known that sprats and herrings are found in estuaries at this age and size, but pilchards have not hitherto been recorded in such localities in England, nor I believe elsewhere on the Atlantic coast. Young pilchards of this age are taken regularly, as described by Professor Marion in the Annales du Musée de Marseille, 1890 and 1891, in the Gulf of Marseilles by seines and other engines worked from or close to the shore.

The Ovaries of Fishes.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

In connection with the inquiries which I undertook at the beginning of the present year into the question of the destruction of immature fish I have been investigating since the issue of the last number of the Journal the development of eggs in the ovary of some flat fishes and the history of the ovary before and after maturity is attained. I have made it my special object to trace the history of the ovary from one spawning period to the next, in order that it might be possible to understand more clearly than at present, from the appearance of an ovary examined at any given time, in what stage of development it was. Mr. Holt has made some observations on this subject, and discussed them in his paper in the number of this Journal for November, 1892. He states there that the first approach to maturity in the ovary is denoted by an enlargement of some of the ova, and the assumption by them of an opaque condition. He terms those ova which have begun to get opaque, "active," and those which have not, "inactive." In a footnote it is stated that the changes which give rise to the opaque condition are not the same in all species, but that they appear to possess the same significance. Mr. Holt leaves undecided the question whether all the active ova are expelled during the spawning period, so that there is a period following the process of spawning when only "inactive" ova being present, the condition of the ovary is not distinguished by internal structure from that of a fish which has not begun to breed, which is immature. He says that he has met with no such condition in the plaice, but that dabs presented such a condition in September after spawning about April. He says that when spent plaice are examined the ovary always contains a number of small active ova, in addition to a host of inactive, but he is uncertain whether the "active" ova represent the early condition of next season's crop, or only ova which, though they pass the inactive stage, are absorbed without becoming ripe. Mr. Calderwood in his paper on Fish Ovaries in the same number of the Journal distinguishes the ova into three stages, the great, the small, and the minute. The great are those to be extruded at the next spawning season, and correspond to the "active" ova of Mr. Holt's paper, while the small and the minute are the "inactive." Scharff in his paper in the Quart. Journ. Mic. Sci., 1888, on which Mr. Calderwood's views are largely based, describes the smaller ova and the larger ova. The latter correspond to the "active" ova of Holt's paper, and Scharff describes the formation of yolk in them, but does not deal with the process in relation to the periodic changes which take place in the ovary.

A comparison of these papers shows that the history of the formation of the yolk in the ova of fishes in connection with the periodic development of the crop of ova which are shed at each spawning season has not yet been thoroughly investigated. My own observations show that the opacity which distinguishes the active ova in Mr. Holt's description is due entirely to the development of the yolk. I will describe what I have observed in the ovaries of various species, commencing with the plaice.

Of the plaice I examined in January some were ripe or nearly ripe and some immature. In the immature ovary the ova are all transparent, and when they are examined with the microscope in the fresh state their structure can be clearly seen. Leaving aside the tissue of the ovary, the stroma, which forms membranes round the eggs, the egg itself is seen to consist of structureless transparent protoplasm containing the nucleus, almost equally transparent, in the centre. The nucleus or germinal vesicle is enclosed by a membrane and contains the nucleoli, rounded bodies distributed at the periphery in contact with the inner surface of the membrane. The appearance of these young yolkless ova in the fresh state is shown in Fig. 1, *a*. In the other fish which are mature, and which are about to spawn, some of these yolkless eggs are present, but they are in small proportion to the opaque yolked eggs which make up the bulk of the enlarged ovary. The yolked eggs are so opaque that it is impossible to see into their interior, but by examination of their surface the yolk can be seen to consist of separate globules or spherules of various sizes. In some specimens eggs which are very nearly ripe and ready for extrusion are seen. These are more transparent, and the transparency is seen to be due to a fusion of the yolk globules into a homogeneous mass. When this takes place, and the egg becomes ripe, the transparent mass of yolk occupies the whole central region of the egg, and the protoplasm forms a thin layer surrounding it. The germinal vesicle cannot be seen in the fresh ripe egg, but it is well known that it is represented by structures which can be demonstrated by appropriate methods in the external layer of protoplasm. It is worthy of note that in the ovary of the plaice, when spawning commences, the ripe eggs are scattered here and there uniformly throughout the germinal tissue, not confined to one place. In other words one part of the ovary does not get ripe before another, but in all parts the eggs ripen in succession, until all are shed.

When all the eggs of the season have been shed the ovary is found in a flaccid, empty condition, the germinal tissue on the walls of the ovary being thin and containing much blood. The fish is now spent. The first specimen I found in this condition last season was obtained on January 28th. The specimen was 24 inches long; the ovary had not shrunk greatly in length, it was 7¾ inches long, measuring from the anterior end of the ventral fin, and the end of it was 4¼ inches from the posterior end of the same fin. In the internal cavity of the ovary a number of detached, ripe eggs were found; these were dead, but fresh, and seemed to have shed after the death of the fish. No ripe or nearly ripe eggs remained in the stroma or germinal tissue of the ovary. When a portion of this tissue was examined it was found to consist chiefly of transparent, yolkless ova exactly similar to those seen in the immature fish, but besides these there were scattered here and there singly, ova which showed a thin layer of yolk granules round the periphery. The appearance of the eggs from a small portion of the germinal tissue is shown in Fig. 1. The yolked eggs were somewhat opaque and presented a dull, unhealthy appearance. The smallest of the yolked eggs was ·27 mm. in diameter, and the largest of the yolkless eggs very little smaller; the largest yolked eggs were ·36 mm. in diameter. I was at first inclined to interpret this condition as

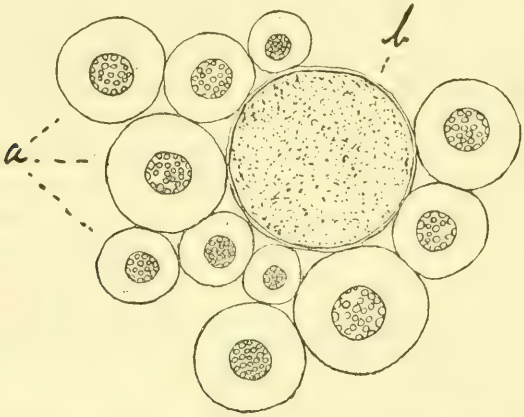

Fig. 1.—Eggs in the ovary of a spent plaice. *a*, yolkless ova; *b*, yolked ovum destined to degenerate.

showing that the formation of yolk in the eggs for the next spawning season had begun by the time the present spawning was finished. This is the condition referred to by Mr. Holt on p. 369, Vol. II of this Journal, and he states that he was uncertain whether the yolked ova represented the early condition of next season's crop, or only ova which remain undeveloped in the spent fish and are absorbed without developing further. The question is, therefore, whether the ripening of the eggs from the immature condition for the next spawning commences before the spawning of one season is concluded, that is to say, whether the development of the yolk takes a little more than, or less than the interval between two spawning seasons.

Examination of other shotten fish, which of course became more numerous as time went on, showed clearly that no advance, but, on the contrary, a retrogression took place in them in the development of yolk. On February 2nd I examined a shotten plaice, 15¼ inches long, in which there were ripe but dead eggs in the cavity of the ovary. In the germinal tissue examined under the microscope there was a good deal of loose yolk from ripe eggs which had been broken during the spawning, but there were no small yolked eggs as in the specimen described above.

On February 24th I examined a female plaice which appeared to be spent from the external appearance of the ovary alone. The right ovary was 3¾ inches long and the distance from the end of it to the end of the ventral fin 3⅜ inches. In immature specimens the length of the ovary is always much less than this latter distance. The fact that it was a spent fish was placed beyond doubt by the presence of dead ripe eggs in the cavity of the ovary. Yet in the germinal tissue itself, when examined under the microscope, not a trace of yolk was to be seen in any of the eggs, the largest of which was ·29 mm. in diameter.

In March I examined no plaice, but in April several, some of which were evidently spent. On April 7th a specimen 14⅝ inches long had a right ovary 2⅞ inches long, and the end of it was 4½ inches from the end of the ventral fin. This fish might, from the size and appearance of the ovary, have been set down as immature, but in the stroma, under the microscope, could be seen here and there shrivelled remains of yolked eggs, much fewer in number than the yolked eggs in spent ovaries previously seen, but evidently of the same kind, and suggesting clearly that the ovary was spent, and reverting to the yolkless condition. Another specimen of the same size, examined on the same date, had the ovary in a similar condition, but the degenerating ova were still fewer in number. The size and external appearance of the ovary in these specimens are not different from those seen in a specimen which is certainly immature.

In May I examined three plaice ; one was a spent female, the right ovary measuring 4½ inches in length, and 4⅛ inches from the posterior end of the ventral fin. There were remains of ripe ova still in the oviduct, and some partially opaque yolked ova in the germinal tissue. The other two were over 15 inches long, and had no yolked ova in the ovary, nor any other indication that they had previously spawned.

In June I examined few plaice. On the 9th I opened a female 14⅜ inches long ; the end of the right ovary was 3⅞ inches from the anterior end of the ventral fin, 3⅝ inches from the posterior end. There were the remains of dead ripe eggs in the cavity of the ovary, but at first no trace of yolked ova was found in the germinal tissue ; afterwards a few shrunken yolked ova were found, evidently in process of absorption.

In July, on the 15th, I first found that the formation of the yolk in the ova of next season's crop had commenced. In one specimen, 16 inches long, the length of the right ovary was 4⅝ inches, its distance from the posterior end of the ventral fin 3⅝ inches. The germinal tissue appeared to the naked eye opaque, white, and evidently yolked. Under the microscope the majority of the ova were seen to contain so much yolk as to be quite opaque, and the largest of them were ·5 mm. in diameter, that is considerably larger than the largest yolkless ova. Fig. 2 shows the appearance of the smallest ova in which yolk had begun to be formed. Nothing was seen to denote that this fish had spawned previously, but considering its large size it probably had.

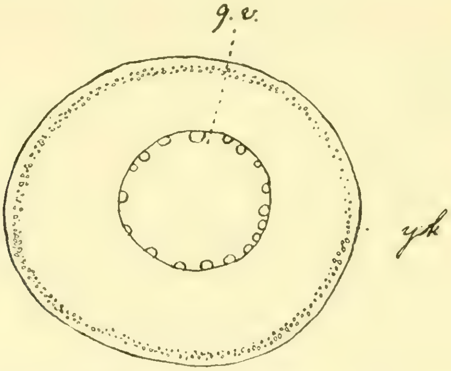

FIG. 2.—Ovum of plaice in which formation of yolk has commenced, magnified about 200 times. *yk.*, yolk ; *g. v.*, germinal vesicle or nucleus with nucleoli at periphery.

Another specimen, 15¼ inches long, exhibited a less advanced stage in the development of the yolk. The right ovary was 3½ inches long, 4⅛ inches from the posterior end of the ventral fin. In the majority of the ova the yolk was present in an external zone of the egg. There was nothing in the germinal tissue to show that this ovary had spawned before, but a small free clump in the cavity seemed to consist of the membranes of old ova of last season.

Another specimen, 14½ inches long, was still less advanced, the yolk being present only as a thin layer of small granules in the most external region of the egg, and the quantity of it was so small that the transparency of the ova was scarcely diminished. Other specimens larger than this last showed no trace of yolk or indications that they had previously spawned, and were either immature, or in the resting condition.

On August 8th I took a plaice from a tank in the aquarium, one of a number which were observed to spawn in the beginning of the year. The specimen was 18⅛ inches long. The right ovary was 3½ inches long and 5¾ inches from the posterior end of the ventral fin. There were no indications that the fish had spawned before. The formation of yolk for next spawning was already somewhat advanced. The largest of the yolked eggs, which were quite opaque, was ·5 mm., the smaller ·2 to ·3 mm.; the largest of the yolkless eggs was ·19 mm. Another large specimen from the same source, killed on August 17th, was found to be in a similar condition.

It is quite certain from these observations that, so far as the microscopic appearance of the germinal tissue is concerned, the spent ovary of the plaice, when examined in the fresh state under the microscope, may be quite similar to an immature ovary. This is clearly exemplified by the specimen described above as examined on February 24th. It is certain, I think, that all the yolked ova left in an ovary after spawning has taken place degenerate and disappear, and the formation of yolk in the succeeding crops of ova does not commence till some time after spawning is over. The earliest date at which I have observed the formation of yolk to have commenced is July 15th. It is also certain that the number of yolkless eggs left in the ovary after spawning is far less than the number of ripe eggs shed in the following season. Consequently the greater number of the eggs of one season's crop are produced *ab initio* during the year. It is to be noted that after a comparison has been made between an ovary in which yolk is commencing to develop and a spent ovary containing superfluous yolked ova the latter cannot be mistaken for ova which are developing for the next season. They are few in number and scattered singly, while the developing ova are abundant everywhere, and they have a dull, unwholesome appearance.

The cases in which I found only yolkless ova in spent ovaries were recognised as spent, like the dabs in the same condition described by Mr. Holt, by the presence of the remains of ripe eggs in the ovarian cavity. Are there cases in which, these remains having been expelled, nothing is left to distinguish a fish that has recovered from spawning from one that has never spawned? I have no evidence by which to answer this question conclusively, but it is certain that ovaries which are known to have previously spawned, from the presence of degenerating yolked ova, are sometimes no larger than others which are, from the absence of any indication to the contrary, set down as immature. For instance, in a plaice, 14⅜ inches long, the spent ovary was 2⅞ inches, and the end of it 4½ inches from the end of the ventral fin, while in a specimen 13¼ inches long, apparently immature, the ovary was 3 inches long and only 4 inches from the end of the ventral fin. To avoid this possible uncertainty in distinguishing immature fish it would be advisable, in order to ascertain the limit of size at which maturity commences, to examine a large number of specimens within a short space of time—one month for example—in the middle of the spawning period. At this time there would be no mature specimens in which yolk had not commenced to develop, and no spent specimens which had reverted to the resting condition.

Dab.

I have not studied the dab in the spent condition, but I have found that the formation of yolk certainly commences in some specimens in September. I killed one specimen 11½ inches long on September 18th; the ovary was 2⅛ inches long, 3⅞ inches from the end of the ventral fin. The yolk formed a thin layer of very small granules in the extreme outer region of the egg, and was not sufficient to diminish its transparency to any great extent. The diameter of the largest of the yolked eggs was ·17 mm. In some of the ova under microscopic examination the membrane of the germinal vesicle was seen to be slightly wrinkled. The appearance of one of the eggs is shown in Fig. 3.

Flounder.

Mature flounders examined in January had ovaries in an advanced condition. In February many were ripe. In July I killed two from the aquarium which were known to have spawned in the spring. One was 11 inches long, the ovary was flaccid and rather large, and did not resemble an immature ovary in external appearance. Microscopically examined, only yolkless ova were found in the germinal tissue, with here and there a shapeless opaque mass, obviously a degenerate yolked ovum left at the previous spawning. In another of the same size the right ovary was 2¾ inches long, 2⅝ inches from the posterior end of the ventral fin, and was in the same condition. These flounders spawned at the end of April and beginning of May, and it is seen that the condition of the germinal tissue had almost reverted to that of the immature ovary, but the size and appearance of the ovary showed that the fish had spawned. Another specimen, 12⅜ inches long, from the same tank, was killed on August 25th; the germinal tissue exhibited only yolkless ova, all traces of previous spawning had disappeared. On August 31st I examined a specimen 15⅝ inches long caught in the Hamoaze. The ovary was large and flaccid, and had evidently spawned before. The formation of yolk in next season's eggs had just commenced, and no trace of the previous spawning was left in the appearance of the germinal tissue under the microscope.

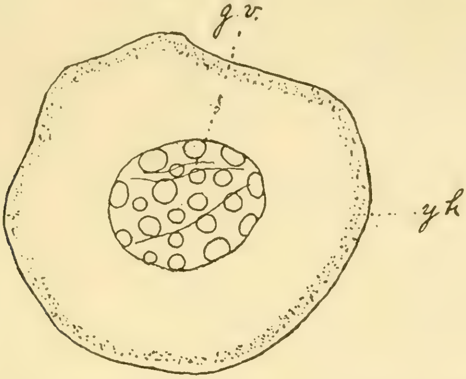

Fig. 3.—Ovum of dab in which yolk has just commenced to develop; magnified about 250 times. *yk.*, yolk; *g. v.*, germinal vesicle with nucleoli. In Fig. 2 the germinal vesicle is shown in optical section, here in surface view.

I have not yet been able to examine the spent condition or to determine the period at which yolk commences to develop in the merry sole (*Pleuronectes microcephalus*). In December and January mature specimens were in an advanced condition but not ripe. Ripe specimens were obtained from February to July, but none in the spent condition.

Common Sole.

My observations on the ovary of this species are far from complete, and I shall hope to resume the discussion of it on a future occasion. From what I have hitherto observed I am inclined to infer that the development of the yolk in the sole extends beyond the period of a year, so that the maturation of one crop of ova begins before the preceding crop has been shed. In January large mature specimens had the ovary in an advanced condition, for instance, in one, $14\frac{1}{4}$ inches long, the right ovary was 6 inches long and $3\frac{3}{8}$ inches from the posterior end of the ventral fin, while the greater number of the eggs were full of yolk and reached a maximum size of ·8 mm. Then there were immature specimens in which the ovary was small, and the ova yolkless, the largest only ·17 mm. in diameter; but in other rather small specimens, whose ovaries were in most respects immature, there were a small number of minute oily drops scattered in the body of some of the largest ova. The question to be decided is whether this condition represented the commencement of yolk-formation for the coming spawning season, or for the season following. I found in one specimen, besides ova in which these scattered droplets occurred, larger ova in which a larger number of globules were present, and evidently constituted the commencement of yolk formation. This specimen was $12\frac{3}{8}$ inches long and the ovary was only 3 inches long, $5\frac{1}{8}$ inches from the end of the ventral fin. As soles have for the most part finished spawning in May it seemed improbable that this specimen was ripening for the approaching season. The condition of the ova is seen in fig. 4.

Fig. 4.

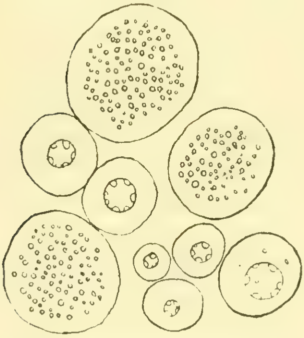

Fig. 5.

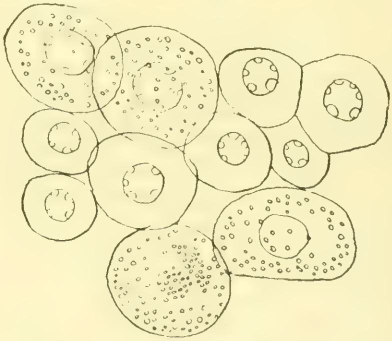

Fig. 4.—Ova from the ovary of a sole $12\frac{3}{8}$ in. long, examined January 27th. Low power.

Fig. 5.—From a sole $12\frac{1}{8}$ in. long, examined February 3rd.

In February specimens between 12 and 13 inches long were found in the condition described, as well as larger fish, which were almost ripe. The condition of the ova in a specimen $12\frac{1}{8}$ inches opened on February 3rd is shown in Fig. 5. The same condition was found also in March, in which month many mature specimens were ripe. In April no soles were examined, but in May some specimens still presented the condition described, while in large specimens diagnosed as spent the minute globules, or the commencement of yolk, were observed in a number of the ova, and seemed to denote, not as in the plaice ova destined to degenerate, but the development of yolk for next season's crop. A number of small soles were examined in June, 6⅝ inches to 10½ inches in length, and in many of these the globules were present in the ova. A more complete study of the sole's ovary, especially in the spent condition, will be necessary in order to fully elucidate the matter, but it is clear that the development of the yolk in this species is somewhat different from that observed in the plaice and flounder. In distinguishing between mature and immature soles I have always set down those in which only the minute globules were present in the ova, or in which the yolk was only just commenced, as immature, since it was evident that such ovaries could not reach the mature condition in the season in which they were examined.

Turbot.

In a turbot, 30 inches long, examined on January 27th, the roe was flaccid and collapsed, evidently one that had previously spawned. Under the microscope the yolk was found to be commencing to develop in some of the largest eggs, while here and there yellowish opaque masses and one or two shrunken dead eggs represented the remnants of the previous spawning. The condition of the germinal tissue in this specimen is shown in Fig. 6. In immature specimens examined on the same date, 15⅝ inches and 17 inches in length, the

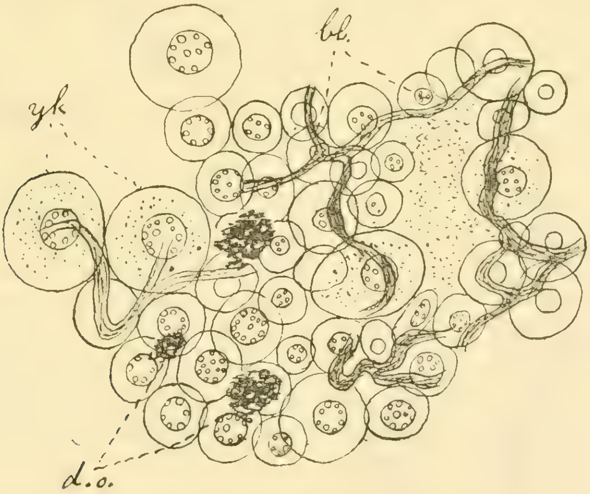

FIG. 6.—Portion of the germinal tissue from ovary of a turbot 30 in. long, examined January 27th. *yk.*, ova in which formation of yolk has commenced; *bl.*, blood-vessels; *d. o.*, degenerate ova left from previous spawning.

ova were all transparent, not a trace of yolk was visible, nor were any degenerating eggs present. A specimen, 19¾ inches, examined on March 4th showed the yolk commencing in an immature specimen, but whether it would have spawned the same summer I cannot be certain. I have not been able to trace the history of spent specimens.

Brill.

A specimen, 16⅛ inches long, on January 25th, had the yolk advanced in development. A few opened in March were ripe, or nearly so.

With regard to the relation of maturity to size, and of the destruction of immature fish, I have not much to add to my paper on *The Immature Fish Question* in the last number of the Journal, but a brief record of a few subsequent observations is necessary.

A few merry soles landed from trawlers were examined in April, May, June, and July, and all were mature, for the most part actually ripe. On June 3rd a specimen, 7⅛ inches long, was taken in our own otter trawl five or six miles south of the Mewstone; it was a female and immature, all the ova being transparent without a trace of yolk. This is the only immature merry sole I have yet obtained at Plymouth.

On May 2nd I visited Brixham to make some inquiries about the fishing there, and ascertained the following facts. Plaice are sold in two classes, the small fish being separated and sold as offal or second class fish, the large in boxes as prime or first class. I saw a quantity of these fish in the merchants' stores, and, though it was impossible for me to take exact statistics, found that the small fish were much more abundant than the large. On measuring I found that the small ranged from 7 inches to 11 inches or 12 inches, and the large from 11 inches or 12 inches to 23 inches. The small fish must be nearly all sexually immature. At Brixham there is a large fleet of small trawlers—about seventy—about twenty tons burthen, as well as larger vessels of forty tons and upwards. The large vessels go long trips and land their fish at various places, while the small vessels fish on the home grounds from Start Point to Portland, and land their fish at their own port. They were accused of throwing overboard fish of smaller size than those they land. Besides the plaice I saw large numbers of small whiting 8½ inches long. Small soles were scarce, and none were under 8 inches. Of lemon soles very few were small, and all I saw were ripe or spent. The smallest I could find measured 10½ inches.

The Devon Sea Fisheries Committee has now prohibited trawling within certain limits in the region where these Brixham trawlers fish.

On May 4th I saw a tuck-net hauled for flat fish at Beesands near Torcross. The mesh of the net was 1¼ inches square. The whole net was 100 feet long, and it was hauled by fourteen men, seven at each end. The catch was very small, a few small fish were thrown back before I saw them, besides these there were thirty flounders 6⅜ to 13¾ inches long, four plaice under 8 inches, and six above, and a few dabs. The men told me that the fishing was unusually poor, but as they have scarcely any market for flat-fish, and use the produce of their seines principally to bait their crab-pots with, it is certain that the seine fishery at Beesands is too small to be of great importance in relation to the destruction of immature fish.

On June 8th I obtained on the Barbican, Plymouth, a number of small soles brought in from Saltash, and probably caught by tuck seines in the Hamoaze. There were twenty-seven altogether, and they were sold for seven shillings. Seven of them were under 8 inches in length, and all except one under 10 inches. Eight were mature males, the rest were immature.

NOTES AND MEMORANDA.

Aphia pellucida, Day (Latrunculus pellucidus, Collett).—An adult male of this species, 2¼ inches long, was taken in the tow-net at the surface south of the Mewstone on June 12th last. When alive it was very transparent, with a few scattered black chromatophores along the back and the ventral edge.

Specialised Organs seen in Action.—As we often can only conjecture the exact function of special organs in marine animals, and opportunity seldom occurs to see them in actual operation, the following observations are perhaps worth recording.

It is well known that the decapod Cephalopoda have, in addition to eight short arms, two others which are long, provided with suckers only on the enlarged terminal portions, and usually retracted into sockets. A specimen of Sepia has for some months past been living in a healthy and vigorous condition in one of the aquarium tanks. At first it injured the posterior end of its body by knocking against the sides of the tank, but having got accustomed to confinement it ceased to do this and the abrasion began to heal up. It was found to catch and devour small crabs with eagerness. In catching this kind of prey it threw itself upon the crab with its short arms spread out, and although the tentacular arms were seen to be protruded this was done so rapidly that the movement could scarcely be followed. When a prawn was offered to the creature much more use was made of the tentacular arms. The prawn moves very slowly and deliberately until alarmed, and then darts away with great rapidity by flapping its tail. It also has the habit of retreating into crevices between the rocks when an attempt is made to catch it. The cuttle-fish accordingly stalks a prawn carefully, to avoid alarming it, becoming at the same time evidently keenly excited, its colour deepening in places and constantly changing, blushing as it were all colours at once. When it gets within a few inches of the prawn it raises its two upper arms and looks like an elephant with uplifted trunk, and then suddenly darts out its two tentacular arms together, seizes the prawn between the clubbed ends, and immediately draws it back within reach of the short arms which close over it and hold it firmly while it is devoured. The stroke of the tentacular arms is extremely rapid and certain in aim. The prawn is seldom missed, and is frequently extracted from a hole or crevice. The cuttle, however, evidently objects to the prawn's rostrum, and always strikes at it from the side, not from the front.

The other case which has recently attracted attention in the aquarium is that of the red mullet, six of which have been living in good condition since August 28th. The mullet is provided with a pair of stiff barbels, about 1½ inches long, attached beneath the apex of the lower jaw. When the fish is swimming above the bottom these feelers are folded backwards and lie in a ventral groove between the edges of the opercula, and in this position are not visible. But the fish does not swim for long, at brief intervals it settles on the bottom, and immediately turns the barbels downwards and forwards, and rakes in the gravel of the bottom with them, keeping them in rapid motion. The barbels are so stiff and strong that they rake into the gravel with considerable force, and in this way the mullet finds worms or shrimps on which it feeds. Even when food is given to the fish on the surface of the gravel, so that there is no need to search for it, the barbels are always used to feel every morsel before the jaws seize it.—J. T. C.

Growth of Fishes in Aquarium.—In the number of this Journal published in November, 1892, particulars were given concerning some dabs and flounders reared in the aquarium. These fish were examined again in the spring of this year, with the following results. Of the dabs twenty-three were taken from the tank and examined on March 3rd, these being apparently all that survived. Fourteen were females ranging in length from 4¼ inches to 8¼ inches, and nine were males from 4⅜ inches to 7¼ inches. To give the lengths in centimetres in order to compare with the measurements of the preceding year they were:

14 females	10·7 cm. to 20·8 cm.
9 males	11·0 „ 18·3 „

With the exception of two females 7¼ and 8¼ inches long, which appeared to be ripening, no signs of spawning were seen in any of these fish, and none were afterwards found to become ripe. This evidence indicates that in the dab as in the flounder few specimens become ripe at two years of age.

The flounders in the small tank, three years old, were examined on the same date. There were only nine of them examined, those which were ripe the preceding year having been removed, and several killed in the interval. There were found—

3 females	8¾ inches to 12⅞ inches.
6 males	7⅝ „ 10½ „

Three of the males were ripe, and the other three probably became ripe later in the season. Two of the females were nearly ripe, and the smallest was killed and found to be still immature.

The flounders in the large tank mentioned in the previous paper were examined on May 13th. There were fifty altogether surviving out of sixty-five counted in the spring of 1892. Thirty-two of the fish were measured and examined; the sizes ranged from 5 inches to 11½ inches. As it was late in the season many of these fish may have finished spawning, only two females showed reproductive activity, one was ripe, and another nearly so. Owing to pressure of other work it was not possible to give more attention to these experiments, but I have thought it worth while to record the sizes and the indications as to the relation between age and breeding.—J. T. C.

Rearing of Fish-larvæ.—From the ripe flounders among the number reared in the aquarium and then three years old last spring I took a number of healthy eggs, and fertilised them. The first lot were hatched on April 20th. They were kept in one of the boxes belonging to the Dannevig apparatus, placed in one of the laboratory tanks. On the 22nd I turned the larvæ out of the box into the tank, protecting the overflow pipe by means of a bolting cloth screen, and keeping a slight but constant inflow of water into the tank. On the 24th the yolk was almost entirely absorbed, and I put in as food some of the minute suspended particles obtained by stirring up finely minced worm in a jar of sea-water. The little fish took this food readily, and could be seen deliberately pecking at the particles in the water. They lived and seemed healthy until April 28th, but then began to diminish in numbers, and on May 1st few were to be seen.

Another lot of eggs procured from the same source were hatched on April 29th, and turned into a tank arranged in the same way two days afterwards. They began to feed on May 4th, and lived well until May 9th, when the numbers began to diminish. I found the dead ones sticking to the screen which protected the outflow. On May 13th two were seen still alive, fourteen days old, and after this date none were left.—J. T. C.

North Sea Investigations.

(*Continued.*)

By

Ernest W. L. Holt.

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'ISH IN THE NORTH SEA.

In subjoining the continued results of my statistical inquiries it is necessary to occupy but little space with introductory remarks, since the question has assumed no new features. The suggestions as to size-limits embodied in the draft report of the Parliamentary Committee would, if carried into effect, leave the North Sea fishery practically *in statu quo.*

It is true that the proposed size-limits would prohibit the sale of some small quantity of fish, of several species, that now finds its way into our markets, but the quantity is so far insignificant that its exclusion would not materially affect the profits of the vessel. I have endeavoured to show that no size-limit that fails to exclude from the market so large a proportion of the immature plaice caught on the Eastern grounds as to render that area unprofitable, is likely

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North Sea Investigations.

(*Continued.*)

By

Ernest W. L. Holt,

Naturalist on Staff in Charge of Investigations.

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I. On the Destruction of Immature Fish in the North Sea.

In subjoining the continued results of my statistical inquiries it is necessary to occupy but little space with introductory remarks, since the question has assumed no new features. The suggestions as to size-limits embodied in the draft report of the Parliamentary Committee would, if carried into effect, leave the North Sea fishery practically *in statu quo.*

It is true that the proposed size-limits would prohibit the sale of some small quantity of fish, of several species, that now finds its way into our markets, but the quantity is so far insignificant that its exclusion would not materially affect the profits of the vessel. I have endeavoured to show that no size-limit that fails to exclude from the market so large a proportion of the immature plaice caught on the Eastern grounds as to render that area unprofitable, is likely to have any effect in increasing the supply either of that or of any other North Sea trawl-fish. No arguments having been brought forward against these views, I am not called upon to defend them further.

Of course I am aware that the difference in the size at which maturity is attained by fish in different districts presents a great obstacle to the formulation of a limit which shall be beneficial to all districts alike. Indeed, I would go further, and say that it is impossible to legislate sensibly by size-limit unless each district is treated separately.

The Procrustean method of cutting down the sizes in all districts to suit the requirements of that wherein the fish are the smallest entirely fails to commend itself to me.

Plaice.—In the last number of this Journal (p. 124) the statistics were carried up to the end of August, 1893, but as a year has now elapsed since I commenced to take the whole number of fish landed, the figures from April, 1893, may now be conveniently recapitulated.

Month.	Total No. of boxes.	North Sea.			Iceland.	
		Total.	"Large."	"Small."	No. of boxes.	No. of "voyages."
1893.	I.	II.	III.	IV.	V.	VI.
April	10,833	10,633	7,964	2,669	200	2
May (N. Sea, less 1 day)	19,859	15,176	7,532	7,644	4,683	20
June	19,555	12,205	5,880	5,325	7,350	30
July (less 1 day)	24,680	13,304	10,585	2,719	11,376	36
August (less 4 days)	19,141	12,287	10,668	1,619	6,854	21
September (less 7 days)	9,887	9,637	9,001	636	250	1
October	16,191	16,191	15,582	609	...	...
November (less 1 day)	11,219	11,219	10,403	816	...	...
December (less 7 days)	4,570	4,570	4,483	87	...	...
1894.						
January	4,463	4,463	4,254	209	...	...
February	3,707	3,707	3,604	70	...	...
March (less 6 days)	6,673	6,673	5,484	1,184	...	...
April (less 4 days)	15,997	14,911	7,844	7,067	1,086	7

I mentioned in my last report that a certain amount of the "small" plaice which appears in the returns were landed by foreign steam-trawlers—chiefly from Hamburg, Bremerhaven, &c. These vessels, in addition to catching what they can with their own gear, occasionally buy up the catches of the small boats on the eastern grounds and bring it across to our markets. It is therefore probable enough that some of the fish so landed is derived from grounds inaccessible to large vessels, but I have not noticed any difference in the quality.

In order to arrive at the quantity landed by our own vessels it is necessary to deduct from each month, as landed by foreign steam-trawlers, the following amounts :

1893.	April	294	boxes.
	May	1642	„
	July	120	„
	November	620	„
	December	87	„
1894.	January	200	„
	March	448	„
	April	2255	„

It therefore appears that the unusually large quantity of "small" landed in the winter months is almost wholly accounted for by the contributions of foreign vessels. Previous to the cholera epidemic at Hamburg in 1892 I am not aware that these large vessels devoted much attention to the small plaice; in any case they did not land them here. Since that period, however, they have frequently landed their fish at this port, and, as I am informed, at Hull also. Last summer they landed several "voyages" of large plaice from Iceland, and from time to time they bring in large quantities of haddocks; but, as a rule, "small" plaice form by far the principal item in their contributions to our market. I do not consider that the difference alluded to, viz. that some of the fish are brought from small inshore boats, is sufficient to justify the exclusion of these foreign-caught fish from the returns, which profess to deal only with fish derived from first-class vessels. A small number of boxes from the Humber and Boston deeps, caught either in small boats or in a net worked from the shore, are not included. Sixty-eight boxes of mature but very small fish from the Baltic, consigned viâ Hamburg to this market, are also excluded. They are dealt with elsewhere in the present report (p. 194).

Remembering that vessels will work the Eastern grounds only when considerable catches can be made thereon, it is possible by observing the fluctuations in columns 4 and 6 to compute roughly the number of boats diverted from the North Sea plaice fishery proper, as apart from the pursuit of exclusively small fish on the area alluded to. Considering this, and taking into account the number of days omitted in various months, it may be inferred that the supply of fair-sized fish increased considerably in May, 1893, since the totals in column 3 remain about the same in April and May, although columns 4 and 6 give evidence of a great diversion of fishing power during the latter month. The decrease of column 3 in June may be partly accounted for, I suppose, by the injurious effects of the prevailing calm on the fishing of sailing vessels, since the increase in column 6 is more or less neutralised by a corresponding reduction in column 4, and so implies but little diversion of the power supplying column 3. This column shows a marked improvement in July; but though in August a still further increase is noticeable (allowing for days omitted), the augmentation of fishing power indicated by the decrease in columns 4 and 6 would seem to show that the supply available for individual boats had on the whole diminished. A further reduction of individual supply may be inferred from comparison of the different columns in September, though the total remains unaffected, or is perhaps rather higher. In October, however, the distribution of power remaining practically the same as in September, we find a very marked increase in column 3, indicating an individual supply not inferior to that of July. This confirms to some extent opinions which I have heard expressed—that the unusually warm spring and summer (of 1893) would be productive of a fine autumn supply. If any such connection exists, the only explanation that occurs to me is that the warm weather has hastened the growth of the fish, so that the annual autumnal recruiting from the small fish on the Eastern grounds has been unusually great.

In November the supply again falls, and this in spite of the landing of individual catches of from 73 to 219 boxes from the "Holman" between the 16th and 23rd of the month; but the tempestuous weather of that month will be within the recollection of every one. While several fishing vessels were lost, many were temporarily disabled, and the consequent paralysis of fishing power is a factor that must be reckoned with in addition to scarcity of fish, which itself is usually enhanced by coarse weather. The lowest ebb is reached in February, but a rapid improvement is noticeable in the succeeding months; April is the only month in which we are able to compare the statistics of two years collected in exactly the same way, and so far as the large fish are concerned, the present year (allowing for days omitted) yields rather better results than the last. The difference, however, is not very great, but there is a very marked increase in the amount of small fish destroyed, indicating that the season is earlier this year than last on the Eastern grounds. It might also be inferred, by the consequent diversion of boats to these grounds, that the individual supply of large fish showed an improvement; but the fact is that a great number of boxes reckoned as "large" contained, during the month in question, only "half-fish." These are mostly immature, but above the limit which, for reasons given in former reports, I have found convenient for separating "large" and "small." The Iceland season is also early this year, or, perhaps, I should rather say that boats have commenced to go there earlier than they did last year. The first voyage had an unfortunate termination, as the vessel ran against Filey Brigg in a fog, and became a total wreck, with a loss of several hands. Some 20 boxes of her plaice, included in the above returns, were brought to market by a yawl, but were condemned as unfit for food. A similar fate befell a consignment of Iceland plaice which reached the market by steamer, viâ Norway, on the same date, the 11th April. They were in very bad condition, and it is doubtful whether such consignments would pay expenses in any case.

As I did not commence to collect statistics of both large and small plaice until April, 1893, it is only possible to compare the catches of 1892 and 1893 by making use of the Board of Trade returns. In the figures given for 1892 (Journal, 1893, p. 84) only the "small" are from my own observations, the boxes of other specification being derived by converting the weight given in the Board of Trade returns into boxes, and eliminating the number of boxes of "small" which appear in my own records. As it is therefore probable that some error exists in the 1892 returns, from inaccuracy of the official figures or of conversion of weight into boxes, I put forward the following results with all due reserve :

1892. Six months, May to October, total, 86,000 boxes.
1893. " " " " 125,000 "

The apparent increase of 39,000 boxes looks promising enough, but is considerably discounted when we find that no less than 30,000 is due to an increase of Iceland fish, leaving a North Sea increase of only 9000 boxes. Examining the columns of large and small, a rough calculation being made, as in the case of the totals, for the days omitted, we find a total of 71,000 "large" and 22,000 "small" for 1893, as against 73,000 "large" and 11,000 "small" for 1892.

The increase, therefore, is entirely confined to Iceland and "small" North Sea fish, while in "large" North Sea fish there is a deficit of 2000 boxes.

Comparing the numbers of "large" month for month in the two years, the fluctuations are much in the same proportion, the chief exception being in July and August. In 1892 nearly two thirds of the total catch of these two months was obtained in the first of them, whereas in 1893 rather more were caught in August than in July.

That plaice are actually decreasing in the North Sea is a fact so generally recognised that it hardly needs illustration, but the present scarcity may not be so apparent from figures dealing with aggregate catches as it becomes when we examine the catches of individual boats. In examining the total figures it must be borne in mind that the fishing power is enormous, our own large fleet being supplemented not only by foreigners, but by vessels hailing from other British ports, such as Scarborough, Shields, Aberdeen, Glasgow, and even Milford Haven.

The scarcity is most felt in the winter months, when, for whatever reason, the fish are very hard to catch. Thus in the last winter a smack failed to average two boxes of plaice in ten consecutive voyages along the neighbouring coast and off Flamborough Head, an area which has the reputation of being fairly productive for the season. The matter may be further illustrated by extracts from some observations of which my friend Mr. R. Douglas permits me to make use. On the 1st February, 1893, a steam-trawler landed one plaice after ten days' fishing, on the 3rd another landed one box after eight days. On the 13th December, 1892, a steam-trawler had three boxes for fourteen days, and on the next day two similar vessels had two each for eight days. These figures are unfortunately by no means so rare as to be exceptional.

A new departure in the trawling industry has been made by the launch, during last year, of several steam-vessels designed for fleeting vessels. Their function is simply to fish, the catch being taken to market and the coal supplied by cutters. As the company to which they belong does not land its fish at this port I have no means of knowing what the results have been, but it is obvious that a steam-vessel, staying perpetually on the fishing ground, is a most powerful engine of destruction,—dangerously so, in fact, in the present state of the grounds.

Haddock.—The appended figures show the total number of boxes of "small" fish landed during the months specified :

1893.	September (less 7 days) . .	4670 boxes.
	October	8457 „
	November (less 1 day) . .	6712 „
	December (less 8 days) . .	5792 „
1894.	January	5248 „
	February	3848 „
	March (less 6 days) . .	5363 „
	April (less 4 days) . . .	8502 „

On the whole the supply of "small" haddock has shown a steady increase since my inquiries were commenced, allowing for fluctuations in individual months. It has so far been impossible to extend the statistics so as to include fish of all sizes, so that I am unable to say what proportion the "small" bears to the total. During the present year, however, I have noticed large catches consisting entirely of "small," a condition not previously observed. So far as I know, the general supply shows no marked decrease.

Cod.—The figures relate to trawled codling, with the restrictions explained in previous reports :

1893.	September (less 7 days) . .	2123 boxes.
	October	2939 „
	November (less 1 day) . .	2491 „

1893.	December (less 8 days)	2730 boxes.
1894.	January	3096 ,,
	February	2607 ,,
	March (less 6 days)	2363 ,,
	April (less 4 days)	1093 ,,

Examination of the returns given in the two previous numbers of this Journal (1893, p. 87, and 1894, p. 128) shows that whatever decrease took place in the summer as compared with the winter months of 1893 is much more striking in regard to the late than to the early months of that year. I drew attention (Journal, 1893, loc. cit.) to the large catches that were made on certain grounds in the winter of 1892–3, and expected that a similar condition would obtain during the next winter. There has been, however, no congregation of small codling on those or any other grounds at all comparable to that of the previous winter. It is true that the aggregate number landed is considerably in excess of last year's supply, but the fish have been brought in in small quantities. Considerable catches first became apparent in November, 1892, and continued to appear until March, 1893. The principal grounds, it will be remembered, were the Yorkshire Hole, and, later on, Flamborough Head. Now a considerable number of boats were working the Hole after the gale of November, 1893, as a fair supply of soles had appeared there; but there was no quantity of codling. In fact, the first record I have of any considerable catches of codling is in February. Seventy boxes is the largest "voyage" (as against 122 last year), and 16 boxes is quite exceptional. "Voyages" of from 60 to 23 boxes are recorded between the 2nd and 5th of March, and thereafter no catches of any magnitude were observed. In all cases the best catches were made during the past winter off Flamborough Head, none occurring at the Yorkshire Hole or any of the other grounds mentioned. The absence of these shoals of codling is evidently not due to scarcity, it is simply a failure to congregate as they did in the winter of 1892–3, and it seems quite possible that the gale of November may have had something to do with it. The fish did congregate, as in the former winter, later in the season off the Head, though in less numbers, and, as our experience is limited to two years, it is not possible to say whether the earlier congregation is a normal feature or the reverse. Answers to inquiries I have made have been too vague to be altogether reliable.

Complaints by deep-sea liners were very general in February of the present year as to the scarcity of cod on the off-shore grounds. The cause, they supposed, was the prevalence of westerly winds, which had apparently the effect of setting the fish into the shore, the best catches being made near the coast. The fish, however, seem to have made their appearance off Whitby in the same month, though the success of different boats in their pursuit showed considerable variety.

II. On the Territorial Fishing Grounds of Scarborough and its Neighbourhood.

In July, 1893, at the invitation of Professor M'Intosh, I took part in some trawling operations which were being carried on by the steamship "Garland" in the neighbourhood of Scarborough, with the object of obtaining soles to stock the Scotch Fishery Board's hatchery at Dunbar, &c. I was thereby afforded an excellent opportunity of making myself acquainted with the condition of the inshore fishing grounds, which, two years previously, had been closed to trawling by an enactment of the North-Eastern Sea Fisheries Committee.

It was claimed by those who had chiefly interested themselves in procuring the bye-law that a considerable improvement had already manifested itself in the local line-fishery, but on that point, from want of any personal acquaintance with the pre-existing conditions, I can offer no independent opinion. I was invited, however, by Mr. J. Woodall, vice-chairman of the committee, to put forward any conclusions which my observation of the present condition of the grounds might suggest as to the desirability of the retention or abolition of the bye-law.

I propose in this note to give a very brief acount of the investigation, and of the conclusions derived therefrom, and I take this opportunity of thanking Mr. Woodall, not only for hospitality extended to myself during my stay at Scarborough, but for a great deal of valuable information as to the fisheries of Scarborough and the surrounding district.

The grounds examined extend along the coast for a distance of a little over ten miles, as the crow flies, from Hayburn Wyke to Filey Brigg. Scarborough lies about midway between these two points, forming the apex of a very gentle general incurvation of the Yorkshire coast-line in this district. The land descends everywhere in rather abrupt cliffs to the beach, which is rocky in general character, though here and there are patches of smooth sand at the water's edge. Beyond low water mark a considerable stretch of land rock separates the area suitable for trawling from the margin, except at Cloughton, where a very narrow strip of sand extends almost to the head of the Wyke, or small bay which bears that name. Beyond the land rock, the existence of various isolated rough patches makes the trawling ground rather intricate, but we were fortunate in obtaining the services of an efficient pilot, and suffered little or no damage to the nets. It may here be remarked that the proper charting of the inshore waters for piscatorial purposes is a duty that might be very profitably undertaken by the fishery authority under whose jurisdiction they fall, since the Admiralty authorities take no account of such physical characters of the bottom as do not interfere with navigation, and the information available from existing charts is, in consequence, lamentably meagre from the point of view of the fisherman or of those concerned in the study of fishery problems.

Speaking generally, our hauls were made along the edge of the land rock, or following the trend of the coast a little further out; but it is also possible, by avoiding certain outlying rocks, to trawl right out to a ground beyond the three miles limit. This ground extends practically from Whitby to Flamborough Head, but we are not at present concerned in discussing its condition. All the grounds I have mentioned are collectively termed the Scarborough "in" grounds. The "off" grounds bearing the same name lie about thirty miles seawards.

The grounds close inshore may for the present purpose be classed together, since we found no great variation in their condition or products, but one of them calls for a little separate notice. This is the Cloughton Wyke Ground, consisting of the narrow strip of sand already alluded to. It has long been famous as a sole ground at the right season, and used to be worked as follows:—At the commencement of the ebb the boat would be taken as far in as the water allowed, the trawl shot and hauled out of the Wyke, thence about two miles offshore and north to another little inlet called Hayburn Wyke. On the flood the *modus operandi* would be reversed, but by far the most soles would always be taken on the ebb. According to my information the soles were chiefly taken near the head of Cloughton Wyke itself, and Mr. Woodall tells me that they were found to feed on a species of Nereis which occurs there in great numbers. I am also informed by Mr. G. L. Alward, on what he considers to be reliable authority, that soles have been dug out of the sand at low water in the same wyke, a statement which the burrowing habits of soles in captivity go far to support.

My own experience of Cloughton Wyke is confined to a single haul, made during the daytime in very clear water. We did not catch any soles, and I am assured that it is only possible to catch soles there in daylight when the water has been rendered turbid by heavy weather from the eastward. Moreover the season for soles had hardly begun. The ground was clean except for a little *Flustra foliacea* and a few hydroids. The fish caught differed in no respect from those taken on the other parts of the inshore grounds. The ground lying to the south of Scarborough was also fairly clean, but elsewhere a considerable amount of rubbish was met with. The commonest hydroid in this, as in any other part of the North Sea known to me, is *Hydrallmania falcata*. Seaweeds are represented chiefly by *Fucus serratus* (near the rocks), and various red weeds (Delesseria, &c). Usually we caught a few edible crabs, and sometimes a lobster, but of smaller Invertebrates other than hydroids and polyzoans my notes mention the occurrence of only *Portunus holsatus*, *Corystes cassivelaunus*, and *Asterias rubens*.

My records deal, in all, with thirteen hauls, and the fish taken on the different grounds may be treated collectively, as, on the whole, one ground yielded much the same as another. Soles, which formed the object of the "Garland's" operations, were decidedly scarce, sixteen and a half pairs being the most obtained in any one night's fishing. They were, however, all fine fish, no immature specimens being taken. We were told that it was too early in the season to get many soles in the trawl, though good catches were being made by the liners. I cannot pretend to say why these fish should be more readily caught on a hook at this time of the year, since we were working practically the same ground as the liners; but such seems to be undoubtedly the case, and it is only one amongst the many features of marine biology which our ignorance at present relegates to the category of mysteries. One can understand that directly after spawning the fish are more hungry, and so take a bait more readily than at other times; but that is far from explaining why they are more successful in evading a trawl at that season. It seems probable that the reason is to be sought in some sessional change in the organisms on which they prey, or in the habits of such organisms. Be this as it may, I record the simple fact on authority that appears to me to be entirely reliable.

Neither turbot nor brill find a place in the list of fish caught, though at one time I am told that the former species was not infrequent in the bay. There is only mention of one lemon sole, a specimen of 5 inches.

In each of two hauls about twenty plaice are recorded; on all other occasions the number was considerably less, so that this fish cannot be regarded as at all numerous during the time we worked. On one occasion we took three of 17 inches; specimens of 14 and 15 inches are mentioned in two hauls; in all the rest the size was smaller, the minimum being 5 inches. Common dabs were only moderately abundant, and most were small. The only other flat-fish taken were three specimens of *Solea lutea*—about two or three miles off the Castle. In Eagle Clarke and Roebuck's "Yorkshire Vertebrata" this species is included as "reported as having been taken at Whitby." Beyond this I find no record of its occurrence on the north-east coast of this country. I know that it occurs regularly on the Well Bank to the south, and it is mentioned by McIntosh as common at St. Andrews, while Edwards says that it occurs also on the coast of Banffshire. The present record points to the probable correctness of that from Whitby, and no doubt the species is generally distributed along the eastern coast. There is, however, no evidence of its occurrence in estuarine waters on this coast.

Turning to round-fish, cod of any size were extremely scarce. One fine fish was taken, and on several occasions we got a few small ones, 5 to 7 inches long. Haddock varied in number, but were comparatively scarce except in two hauls, when we took a great number from 5 to 9 inches long. Very few on any occasion exceeded a length of 12 inches. Whiting were much more abundant as a rule, and varied in size from 3 to 14 inches. In one haul, when the cod end was enclosed in an outer bag of fine mesh, a considerable number less than 6 inches in length were caught, but when the outer bag was removed very few of these very small fish came aboard. I noticed also a decided improvement in the quality of the fish towards the end of our operations, since, while in the earlier hauls immature specimens (*i. e.* less than 9 inches long) were in the majority, the numbers were equalised later on, and sometimes the mature fish were actually the most numerous. It was evident that a movement was taking place amongst the larger fish, having the effect of driving the small ones elsewhere, since I have found that cannibalism is highly developed in this species. In reporting on the Humber fisheries in previous numbers of this Journal I have already adverted to the great sessional irregularity of the movements of whiting in inshore waters, and can only now repeat that the conditions at a given time in one year cannot be relied on to hold good for others.

Gurnards were always fairly abundant, but the number of small always exceeded that of the large, except in the last haul but one, when the large fish were in a decided majority. These fish, therefore, appeared to be undergoing a movement similar to that noticed among the whiting. Several very small herring and a few thornback rays were taken, completing the list of food-fishes, unless we include the monk or angler in this category. Several of the latter were taken, none of very large size. Unsaleable fishes were represented by a few "hard-heads" (*C. scorpius*), "bull-routs" (*A. cataphractus*), lesser weevers, and dragonets.

To review the above results briefly, we may say that the investigation showed that the fish forming the object of a legitimate trawl-fishery were confined to a few whiting, gurnards, and dabs, a very moderate quantity of soles, and an infinitely minute number of plaice and cod. On the other hand, a rather large quantity of undersized haddock, whiting, and gurnard were thereby destroyed; while the destruction of small plaice, though not great in actual numbers, was very considerable in regard to the local supply of this species.

It is evident, therefore, that there is a *primâ facie* case against trawling on these grounds at this time of the year, merely because the waste is in excess of the products. We may consider the matter from another point of view, viz. whether the consumer can be adequately provided by means other than trawling. This question may be so limited as to deal only with the soles, since these are the only important product which cannot obviously be obtained without encroaching on the three-mile limit; and here we find an answer in the affirmative. While our best night's fishing yielded only 16½ pairs, and our catch was usually much less, 25 and 18 pairs were respectively taken by two cobles line-fishing on these grounds during one night of our stay at Scarborough. Such success was not exceptional, and I do not think a coble ever caught so little as we did on any one night. That the catches of the "Garland" are no fair test of what may be achieved by trawling is an objection which may be urged with some show of reason so far as concerns any one night's fishing, since it is well known that a sailing vessel will trawl more soles than a steamer if both are fishing side by side over the same ground. But when we consider the dependency of a smack on the wind, and the intricacy of these particular grounds, I think it may fairly be assumed that a sailing vessel would not have materially improved upon our aggregate catch during the week. I therefore consider that the interests of the consumer can be sufficiently served by line-fishing.

Policy in fishing matters is too often degraded to the merely social aspect of the case, viz. the relative claims of local and other fishermen, or of the local liners and trawlers when the two industries co-exist in the same fishing community. With this I have nothing whatever to do, but may remark that, according to my own experience, one class is burdened with about as much providence and public spirit as the other.

I did not neglect, while at Scarborough, to make inquiries as to the effect which the territorial restriction of trawling was thought to have had on the inshore line-fishery, but as evidence on this subject was given before the Parliamentary Inquiry, in some cases by the men who were my own informants, I need only refer to the matter very briefly. It was asserted that the sole fishery had very greatly revived since trawling was forbidden in these waters, and I have no doubt that this is the case. It requires no argument to show that trawling and lining cannot be carried on together in one limited area without injury to the latter industry.

As to the haddock fishery, I was told that the trawlers still encroach so much on the territorial haddock grounds that not much benefit has been felt by the liners. These grounds lie further out than those on which the soles are chiefly caught, so that the sole-fishery is not affected by this poaching. The matter is therefore of less general importance, but owing to the amount of undersized fish on the ground it could not but be beneficial to enforce the bye-law in its entirety.

III. The Blonde (*Raia blanda*, Holt and Calderwood, MS.), a Species hitherto confounded with *R. maculata*, Montagu.

In collaboration with Mr. Calderwood, I have been engaged, since I first entered the Association's service, in attempting to revise the British Rajidæ, and one result of our efforts has been the discovery of a species which has hitherto escaped separate description. It seems, therefore, advisable to put forward a brief diagnosis at once, reserving a full description to another occasion.

The species was first met with by one of us on the west coast of Ireland, but the large size of the only specimens obtained rendered it impossible to define it in a satisfactory manner. Recently, however, we have had the good fortune to obtain a nearly complete series from the North Sea, and there can be no doubt of its distinctness.

In the appended diagnosis especial stress is laid on those points which serve to distinguish the species from the closely allied *R. maculata*.

Size.—Reaches a width of over 30 inches; males become sexually mature at a width of 24 inches or more; the egg-purse about 5½ inches long, exclusive of attachment processes.

Shape.—Anterior profile obtusely rounded, the extremity of the snout projecting in a short *semicircular* process, except in adult males, where it is more or less conical, *never sharply pointed.* Anterior margin with two salient curves, varying in degree according to age and sex. Tail rather broad anteriorly, and distinctly flattened in old examples.

Proportions.—Width of the disc about twenty-five per cent. greater than its length, and about thirty per cent. less than the total length; the tail slightly the longer in males. The length of the snout from 4¾ (in young) to nearly 5½ times (in adults), and the distance from the tip of the snout to the coracoid from 2½ to $2\frac{6}{11}$ times in the width of the disc. The distance between the nostrils equal to or rather less than their distance from the tip of the snout. The length of the eye from $1\frac{1}{2}$ (young) to 2 times (adults) in the distance between the supra-orbital ridges, which is equal to, or in large examples greater than, the combined length of the eye and spiracle.

Dentition.—Teeth small; obtuse in females and immature males, sharply pointed in adult males; arranged in from less than sixty to over ninety rows in the upper jaw.

In specimens about 9 inches across the disc about 66 rows.
,, ,, 16 ,, ,, 74 ,,
,, ,, 23 ,, ,, 78 ,,
,, ,, 29 ,, ,, 93 ,,

Spinulation.—*Upper surface.*—A few spines at the end of each orbital ridge and along the rostrum in young examples; the former frequently, the latter always wanting in adults. A spine on each shoulder in young examples may persist until a large size is attained. Exclusive of sexual alar spines, the other large spines typically in a median row from the head to the dorsal fins, the last spine between the dorsals, and in a lateral row on each side of the tail. These rows are formed by a young and adult series, the young series of the lateral caudal rows being frequently lost before the old series appears. The latter usually very imperfect in males, but double in its anterior region in females. The young series of the median row often imperfectly replaced, except on the tail, in either sex. Very large examples may have lost nearly all the adult median series. Of the median series in young examples, three or four, *always more than two,* spines are in front of the pectoral region.

Small asperities confined to the pre-pectoral region of the disc in young examples, *extending all over the disc* in half-grown fish of either sex and in adult females. Gill region and central area of the pectorals smooth in adult males.

Under surface.—Young examples (9 inches across disc) with a *narrow border of very closely set asperities along the anterior margin,* not extending to the angles of the pectorals. A similar border, in rather larger examples, along the edge of the tail. Under surface otherwise smooth. Some asperities about the region of the coracoid and anterior part of the abdomen in half-grown examples of either sex, and about the general surface of tail in females. The anterior border increases in width with age, and in old males, rarely in old females, extends backwards over a great part of the snout. Adult females in addition have scattered asperities over the whole under surface, except the outer parts of the paired fins.

Colour.—The upper surface a pale fawn, may incline to chestnut, rarely to cold sepia; usually darker over the abdomen and lighter on the head than elsewhere. Thickly sprinkled with small dark brown spots, rarely exceeding ¼ inch in diameter, *which extend to the margins of the disc.* A number of small pale rounded areas, with a certain bilateral symmetry of arrangement, on the wings, each area surrounded by a ring of spots not larger than the rest, and never coalescing with each other; occasionally a central "pupil" spot. Under surface white, sometimes a little brown on the tip of the snout.

* * * * * * *

It will be seen from the above that the new species differs from *R. maculata*, Montagu, in many points. Comparing specimens of equal size, the eye is smaller, the teeth smaller and more numerous, and the distance between the snout and the coracoid greater in *R. blanda* than in *R. maculata.*

The difference in spinulation is very strongly marked, since *R. maculata* never attains anything like the same development of the asperities of the upper surface, as is present in half-grown *R. blanda.* The anterior border of asperities on the under surface is also entirely wanting in *R. maculata*; the greatest degree of ventral spinulation attained by that species throughout life taking the form of a few scattered asperities on the snout, about the pectoral region, and on the tail. Moreover the maximum width attained by *R. maculata* hardly exceeds 20 inches, and its egg-purse only measures about 2½ inches exclusive of attachment processes. Though the size of the spots on the upper surface is subject to variation, they are always larger and more numerous than in *R. blanda* of the same size, and never extend to the margins of the disc. In some examples they are altogether absent. There may or may not be a single conspicuous ocellus on each wing, but if present it is always surrounded by a ring of largish spots, which are frequently more or less coalesced; such an ocellus is always larger than any of those exhibited by *R. blanda,* and though other pale areas may exist on the wings of *R. maculata* they are never at all distinct.

There are a number of spotted rays found in the South Atlantic and Mediterranean, which all appear to possess the anterior border of ventral asperities, but are yet specifically distinct from *R. blanda.* The species which most closely approach it are *R. asterias* (Müll. and Henl.) and *R. punctata* (Risso); but of these the former, besides differing conspicuously in colour, has a very much larger mouth, while the latter, a very small species, has much larger teeth than *R. blanda.*

A species described under the name of *R. brachyura* by Lafont (Soc. Linn. Bordeaux, xxviii, 1873, p. 503, pl. xxv) may possibly be identical with *R. blanda,* but the description is very meagre and the figure primitive. It is impossible from the context to be certain whether a statement that there are no "aiguillons" on the ventral surface precludes the presence of such asperities as are present in *R. blanda ;* while the figure, so far as it resembles anything that is likely to have an actual existence, is more like *R. asterias* than *R. blanda.* It having proved impossible to procure specimens of a spotted ray from the same locality, we are compelled to pass the species over as insufficiently defined.

Turning to British authors, Montagu's descriptive remarks apply only to the smaller British species of spotted ray, the varieties he mentions being merely colour phases. He states, however, that *R. maculata* grows to a larger size than *R. clavata,* which is not the case in any district with which I am acquainted. It is therefore possible that he knew the larger species, but did not recognise it as distinct. However, as his description is obviously based on the smaller, his claim as sponsor thereto holds good.

Day's figure of *R. maculata* is undoubtedly taken from an immature male of *R. blanda,* which appears from the scale given to have been about 25 inches across the disc. The author remarks that in this specimen the spots were rather closer together than usual, but the drawing does not strike one as a very successful illustration of either species. The description given in the text refers chiefly to the smaller species.

Couch evidently selected a specimen of *R. blanda* for special description, but his general remarks apply to both species, and his figure specially to neither, though probably taken, at least as far as the spots are concerned, from *R. maculata.* Subsequent to the publication of his work on the British fishes, the late Dr. Day described as new to Britain a spotted ray which he considered to be identical with *R. punctata,* Risso. It was stated, possibly by a clerical error, that the teeth were larger than those of *R. maculata.* The identity of the specimen is now lost, but the Day collection, now in the British Museum, contains a small spotted ray, which bore no label when received at South Kensington. It is undoubtedly a young example of *R. blanda,* but it remains uncertain whether it is the specimen recorded as *R. punctata.*

But if our ichthyologists have hitherto failed to distinguish between *R. maculata* and *R. blanda,* the same reproach cannot be urged against our fishermen and fish merchants. Under the names of Homelyn and Blonde, or Blund, respectively, these two species have long been recognised as distinct at Grimsby, and presumably at the other great fishing centres of the North Sea. It is true that, owing to the scarcity of young blondes, many are unable to distinguish the latter from homelyns, but certain specific characters are well enough known to those specially engaged in the skate trade. The name "blonde" is said to have been derived from the Belgian fishermen, with what truth I know not; and in naming the species *R. blanda* we have made use of the Latin epithet which assimilates most closely in sound to the vernacular name in general use.

In conclusion we may be permitted to express our indebtedness to Dr. Günther for advice and references, and especially for invaluable aid in the comparison of specimens at the British Museum. Indeed, I may add that it was chiefly at his instigation that those inquiries were instituted which have now resulted, as I trust, in finally establishing the distinctness of the two species.

IV. The "Recessus Orbitalis," an Accessory Visual Organ in Pleuronectid Fishes.

I have applied the above name to a structure described in a paper read before the Zoological Society, of which the present remarks are a brief abstract. It first came under my notice when examining the cephalic anatomy of a common sole, but as I could find no mention of it in Cunningham's Treatise on that species, I supposed that the specimen before me might be exceptional. It proved, however, to occur regularly, not only in the sole, but in all other Pleuronectids which I examined, viz. the halibut, long rough dab, brill, plaice, flounder, and lemon "sole." The material at my command proving unsuitable for a study of its development, I am unable to form any very valid opinion as to its homologies, and can only put forward what I know of its condition in the adult.

The *recessus* in those species in which it is most conspicuously developed consists of a diverticulum of the membranous wall of the orbital cavity. It is sac-like in form, with very delicate membranous walls, except where the latter are traversed by anastomosing muscular bands. Such bands may also cross the lumen of the sac, and may even form more or less complete septa. The *recessus* of the lower eye lies below the skin immediately behind the eye, occupying a space bounded by the anterior face of the superficial jaw muscles, the backward continuation of the interorbital septum and the membranous wall of the orbital cavity. With this cavity it communicates by one or more rather large openings with thickened rims, and frequently by other smaller openings, the whole number being rather close together, and variable within the limits of a single species. In the brill the *recessus* of this eye is in the form of a conical process of the membranous wall, of which only the apex is strengthened by internal muscular apparatus. In the halibut there is no definite sac in connection with the lower orbit, but a portion of the membranous wall is differentiated by the development of numerous interlacing muscular bands, backed by very delicate membranous sacculi. The condition first described, actually met with in the plaice, is sufficiently applicable to the other species mentioned.

The *recessus* of the upper eye is in all cases a definite sac, always larger than its fellow of the lower eye, and always situate on the blind side of the skull, and to some extent overlaid by the superficial jaw muscles of that side. It communicates with the upper orbital cavity by a narrow neck, which passes through the large foramen between the pseudo-mesial process of Traquair and the parasphenoid. It is essentially similar in internal structure to the fully developed organ of the lower eye. Its shape depends merely upon its topographical relationships.

In the fresh condition the *recessus* of either eye, when sac-like in form, is colourless and quite translucent, except for a slight milky opacity where the muscular bands are most numerous. It is, as may be supposed from the description of its internal structure, highly elastic, and is filled in life by a colourless fluid also present in the orbital cavity. It is rather richly supplied with blood-vessels, distributed on the inner face of the sac when such is present, and we may assume, as in the case of peritoneal and synovial cavities, that the fluid is deposited by mechanical filtration through the blood-vessels. In any case I have been unable to detect any special secretory apparatus in the epithelium of its walls. The only source of innervation which I have discovered is from the V. cranial, whether from sensory or motor roots I am as yet unaware.

The fluid coagulates after a time into a milky white plasma, finely granular in microscopic preparations, and taking on a faint pink stain from borax carmine, but the *recessus* retains its elasticity for some considerable time after death. Thus, if the eye is pushed inwards, the fluid is forced into the *recessus*, which thus becomes enormously distended; but as soon as the pressure is relaxed the *recessus* contracts, and the eye rises to its former level.

It will be familiar to those who have observed the habits of flat-fish in aquaria that the eyes are normally protracted to a considerable degree. If the fish is frightened by placing some object near the eyes, the latter are immediately withdrawn into their sockets, while a corresponding inflation may be observed in the region of the *recessus* of the lower eye—the only one which can be seen. As soon as the object of terror is withdrawn the eyes rise again. Now there is no protracting apparatus in the muscles of the eye, and it is evident that the mere relaxation of the oblique and recti muscles would be quite insufficient to protract so heavy an organ as the eye to the degree actually attained. It is therefore evident that this result is attained by the pressure of the fluid contents of the orbital cavity, and that the *recessus* is functional in regulating these vertical movements,—in affording an outlet to the fluid of the orbital cavity when the eye is withdrawn by the contraction of the recti and oblique muscles, and in protracting it when these muscles are relaxed by driving back the fluid into the cavity. Its action appears to be almost if not wholly involuntary; but though one might expect to find a connection with the sympathetic system, I have not succeeded in doing so.

According to my observations, limited to Pleuronectes, Solea, and Rhombus, the power of protraction is possessed in degrees corresponding to the order in which I have named these three genera, and the *recessus* is developed in the same degree. That the organ of the upper eye is always the larger is explained by the condition of the orbital cavity. That of the lower eye is in part bounded only by loose skin, which allows some play to the elasticity of the undifferentiated part of the membranous wall when the eye muscles are contracted, and is also sensible to the pressure of the external element when the muscles are relaxed. The upper orbital cavity, however, bounded as it is by the skull and firm dorsal muscles, is wholly dependent on its accessory organ as an outlet for the fluid. The eye, in fact, could not possibly be retracted if no *recessus* were present. The great inequality in the accessory organs of the halibut, which exhibits the minimum development of the lower and the maximum of the upper *recessus*, is probably due to the convexity of the head, whereby the lower eye is set in a higher plane than the upper, which is also much nearer the dorsal ridge than in the other species studied. Hence it is evident that the pressure required to raise both eyes to the same level must be very unequal, but I have no means of saying from actual observation that the eyes are protracted to the same plane in life.

A pouch-like diverticulum of the membranous wall of the orbital cavity was discovered many years ago by Dr. Günther in *Chorinochdismus dentex*, one of the Gobiesocidæ. So far as I can tell from examination of the organ in a specimen that has been a very long time in alcohol, it corresponds well enough to the *recessus* of flat-fishes. Dr. Günther conjectured that it might represent a *saccus lacrymalis;* but though I am loath to speculate on this subject without a knowledge of its development, I am bound to say that the relationships of the organ to the orbital cavity do not appear to point to this homology. The organ lies between the eye and the maxilla, but the different position of the *recessus* of the lower eye in a flat-fish is only such as would be brought about by the rotation which we know to take place in the eye of a metamorphosing Pleuronectid larva. A difference in the levels of the eye in the British Museum series of *C. dentex* suggests that the function of the organ is similar to that which I have demonstrated in the case of the *recessus ;* and very probably this structure, which I suspect to be no more than a specialised portion of the membranous wall, not homologous with any known visual organ in higher animals, may prove to have a wider distribution than is at present known to us.

V. ON AN ADULT SPECIMEN OF THE COMMON SOLE WITH SYMMETRICAL EYES, WITH A DISCUSSION OF ITS BEARING ON AMBICOLORATION.

Under the above title a detailed description of the specimen in question was communicated to the Zoological Society at a recent meeting. The fish is a female 15 inches long, differing from a normal specimen in no external feature of note except that the left (normally the upper) eye is nearly opposite to the right. The eye is partially withdrawn below the skin, and its vision doubtless must have been to some extent further impeded by the sensory filaments, which extend right up to the periphery of the cornea. Still, without doubt, the fish could see reasonably well with this eye. The left side is colourless, and the effect of the eye, which had the iris of the normal colour, peering out from the dead white surrounding region, was very striking in the fresh condition. On examining the skull it was found that the union of the left ectethmoid and sphenotic into the " pseudo-mesial process " of Traquair had taken place as usual, and had taken on its usual fibrous connection with the large ligament bone which underlies the interneural spines of the anterior part of the dorsal fin. The abnormality of the skull was, in fact, limited to a slightly less development of the left ectethmoid, especially of its anterior spur, and the greater size of the very variable foramen which exists between the pseudo-mesial process and the parasphenoid. This foramen normally gives exit to a cranial nerve, and puts the left *recessus orbitalis* into communication with the left (or upper) orbital cavity ; but in the specimen before us it is traversed by the muscles and the optic nerve of the left eye. The muscles have precisely their normal attachment, and the left ectethmoid has undergone the normal rotation. The eye rests internally against the pseudo-mesial process, and the general arrangement of the parts suggests that it has been drawn by the rotation of the attachment of the oblique muscles as far inwards as the interposition as the pseudo-mesial process has permitted it to go.

The question of ambicoloration is dealt with at some length in the paper, but the exigencies of space only permit me to notice a few points. In the first place it is evident that the occurrence of a normally coloured flat-fish with practically symmetrical eyes renders it evident that there is no necessary connection between the ambicolorate condition and the partial arrest of the migration of the upper eye met with in so-called "Cyclopean" examples. In making full reference to the recent important memoir of Messrs. Cunningham and MacMunn on the *Coloration of the Skin of Fishes* (Phil. Trans., 1894, p. 765), such additional material as I have examined points to a general acceptance of the opinions on ambicoloration therein formulated, but several minor details require a few words. Thus the restriction, apparent from the examples studied by these authors, of pigmentation of the lower side to the region posterior to an imaginary line drawn through the pre-operculum, in partially ambicolorate but structurally normal turbot, does not hold good in the case of one which has recently come into my hands. No malformation is apparent, but the anterior border of the continuous pigmentation is formed by a line which passes from the origin of the dorsal to the angle of the preoperculum, and thence forward again across the lower part of the gill cover to the anterior end of the isthmus. In addition, the maxilla and a great part of the mandible are also coloured. Accordingly, while admitting that Cunningham and MacMunn's limitation covers the great majority of cases, we must hold that any degree of ambicoloration, short of completeness, may occur in the turbot without apparent structural abnormality.

The authors note that reliable records of the "Cyclopean malformation" are limited to certain genera and species, which do not include the sole, but are unable to discover any "correlation between the occurrence of this malformation and any peculiarity of the species in which it occurs." So far as the sole is concerned, this species has a skeletal peculiarity in the form of a great blade-like ligament bone interposed between the base of the front part of the dorsal fin and the top of the skull, which is not present in any of the genera in which the malformation has been observed. Taking into consideration the relationship of the parts concerned in the malformation, I suggest the possibility that this feature may supply the missing correlation. It is also possible, and perhaps more likely, that the burrowing habits of the sole would be fatal to the survival of a "Cyclopean" example of this species, since the length of the "hook" necessitated by the great forward extension of the dorsal would be a serious impediment to it, while all available evidence supports the opinion of the authors that their abnormal flat-fish do not differ at all in habit from their normal brethren.

The authors note the frequent occurrence in the brill of a form of ambicoloration in which spots of pigment occur in a series along the interneural and interhæmal regions of the lower side, and Bateson (in a communication to the Zoological Society which I have not yet in print) has pointed out that these spots are symmetrically arranged with regard to the numbers of the dorsal and anal fin-rays. I do not find it stated, however, that these spots are obviously the survivors of those which are so conspicuous in the metamorphosing larvæ of nearly all flat-fish, and which occur, moreover, in the larval condition of many round-fishes. Further, the same series of spots are retained throughout life on the ocular side of some of the smallest Pleuronectids (*e. g.* *Rhombus norvegicus*), and I am strongly of opinion that the frequency of this form of ambicoloration in the brill points to atavism as an important factor in ambicoloration generally. Messrs. Cunningham and MacMunn cite a difficulty in the way of this interpretation of atavism, which I am unable to appreciate. It is that the "symmetrically vertically swimming ancestor of the flat-fish" must have had "an unpigmented white or silvery ventral surface, as other symmetrical fishes have," whereas in an ambicolorate flat-fish the dorsal and ventral regions are equally pigmented. But vertically swimming fishes are not all pale on the under surface, such forms as Platax and Dascyllus, in remotely related families, being as dark below as above; and it is surely reasonable to suppose that the flat-fish of to-day were derived from high laterally compressed fishes such as these, rather than from round-fish of the ordinary type. Even flat-bellied round-fish living at great depths may be as dark, or darker on the belly than on the back, as in the case of *Macrurus æqualis*; and I do not see why the fact, so ably demonstrated by Cunningham, that the colourless side of a flat-fish may retain the power of pigment production under favourable conditions of light, should not suggest to us that the pale ventral surface of a round-fish may be potentially darker, or even as dark as the dorsal region.

Another point which appears to me to distinctly hint at atavism as a factor in ambicoloration is the constant or very usual co-existence of what one may term "ambiciliation," *i. e.* the dermal armature is much more equally developed in ambicolorate than in normally coloured flat-fish. It is difficult to see how this can depend on the light, while it is quite intelligible that any reversion of the derma should react equally on the colour and the armament.

VI. THE REPRODUCTION OF *Caranx trachurus*, LINN., THE SCAD OR HORSE-MACKEREL.

In my paper on the eggs and larval and post-larval stages of Teleosteans taken during the survey of the west coast of Ireland ("Sci. Trans. R. Dub. Soc.," vol. v, ser. 3, p. 9), I included some notes on the intra-ovarian egg of this species, as to the development of which no previous information was forthcoming.

The material then at my disposal seemed to justify the conjecture that the ripe egg would be found to be pelagic, and similar to that of the mackerel, only smaller.

I am now able to describe the ripe unfertilized egg, having obtained a number of spawning females from the North Sea on the 19th May, 1894. Ripe males were obtained on the same day, but the milt appeared in bad condition; at all events, an attempt at artificial fertilization proved unsuccessful.

The fish, which were stated to have been caught on the previous day, appeared perfectly fresh, and on pressing those which appeared to be gravid the spawn was readily discharged. Somewhat to my surprise, the ripe ova were in most cases accompanied by a great number which were still opaque, though only gentle pressure was applied. When only ripe ova were ejected the whole mass had a distinctly yellowish colour, which I subsequently found to be caused by the fact that the oil-globule is usually of a bright orange colour to the naked eye. Under the microscope, whether by reflected or transmitted light, the globule appears cupreous. In the spawn of one individual the globules were practically colourless.

The eggs, for the most part, were not spherical, but were quite translucent, and floated buoyantly in the *estuarine* water of the Cleethorpes tanks. I estimated the diameter, in the spherical condition, to vary from 1·03 to 1·09 mm. The diameter of the oil-globule, when only one was present, varied from ·26 to ·27 mm., but some ova, when first extruded, exhibited two or three smaller globules which soon fused into one. *Motella mustela* and *Trigla cuculus* show a similar, if less rapid, fusion of the globules after deposition, and the last-named species also illustrates a similar variation in the coloration of the globules.

The zona, in the species under discussion, is very thin, and is sparingly and rather irregularly dotted with minute vesicle-like markings—a character noticeable in the newly deposited ova of many Teleosteans.

The chief peculiarity occurs in the yolk, which in the ova that seem to be ripe is perfectly colourless and translucent, and divided throughout its substance into a number of segments of varying size. The segments are mostly more or less rounded in outline, and the general appearance can be more aptly compared to that of a mass of small bubbles than to anything else. Fig. 1 shows the surface of such an ovum. It will be noticed that the segments do not overlie any part of the oil-globule, which appears invariably to occupy a small area of unsegmented yolk-substance. In most ova this area is confined to the immediate neighbourhood of the globule, but in one it occupied at least one third of the whole yolk mass. The segmented area was evidently encroaching by the formation of fresh segments, as during the time I had the ovum under observation, a vesicle which appeared at first to be united by a narrow neck to the undifferentiated region became entirely separated from it. The process was probably taking place over the whole area, but it was only possible to observe the final constriction in the case of this particular segment, as none of the others were in profile. I conclude that the formation of the yolk segments takes place after the hyaline enlargement of the ovarian egg has manifested itself, and, so far as my observations go, it appears to extend gradually from pole to pole. I am inclined to suspect that it may extend more rapidly along the periphery, since in examining some ova immediately after extrusion I failed to satisfy myself that the central region was segmented. Others, however, at the same stage, and all older living ova examined, were segmented throughout.

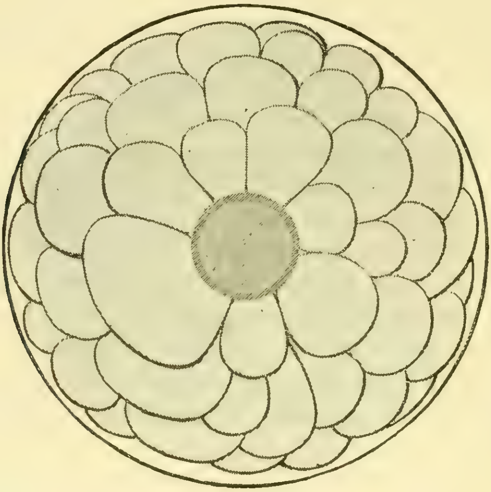

Fig. 1.—Unfertilized egg shortly after extrusion.

I attempted artificial fertilization, but do not think it was successful. Forty-eight hours later all the ova were dead, except a few kept in a vessel to which no milt had been applied. These last presented the appearance shown in Fig. 2. A very slight perivitelline space had appeared, and there was a small and slightly opaque blastodermic cap: the character of the yolk was unchanged, and the eggs still floated.

The dead ova in all the vessels, whether supplied with milt or not, exhibited a similar blastoderm, which, as is well known, frequently appears without fertilization. The yolk presented a peculiar appearance, the segments being restricted to an irregular mass underlying the blastoderm (Fig. 3). None were visible in the vegetative third of the yolk mass, nor did they extend, as a rule, to the periphery in any region. The blastoderm was opaque and granular, as was also, but to a less degree, the unsegmented part of the yolk,

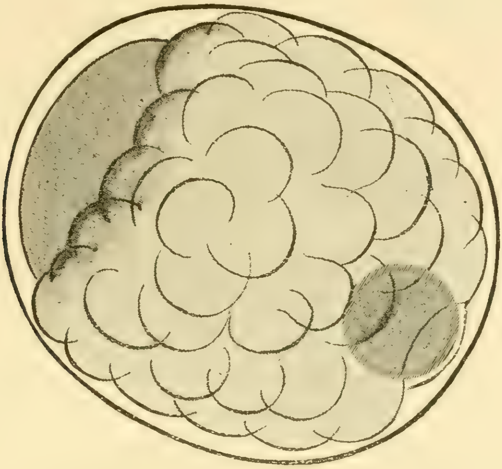

Fig. 2.—Living unfertilized egg forty-eight hours after extrusion.

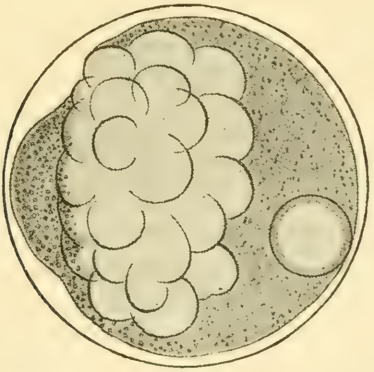

Fig. 3.—Dead unfertilized egg forty-eight hours after extrusion.

The segmented part, however, retained in great measure its former translucency, but the segments, especially those near the surface, were very irregular. I consider that this condition was arrived at by decomposition setting in from the periphery, involving the breaking down of the peripheral segments, and not by a shrinkage of the segments towards the central area.

To recapitulate: the egg of the scad is pelagic, and measures about 1·03 to 1·09 mm. in diameter before fertilization; it possesses a single oil-globule, ·26 to ·27 mm., either colourless or of a bright orange colour (and probably of any intermediate tint), which presumably disappears more or less with the development of the egg. The perivitelline space is probably small. The yolk is colourless, and segmented throughout, the segments in early stages having a very characteristic vesicular appearance, not noticeable in the ova of Clupeoids.

So far as I am aware, no other acanthopterous fish is known to possess an egg with completely segmented yolk. The existence of this feature in such widely separated families as the Clupeidæ and Carangidæ seems to show that it is of no taxonomic importance.

VII. On a Dwarf Variety of the Plaice (*Pleuronectes platessa*, Linn.), with some Remarks on the Occasional Ciliation of the Scales in that Species.

On the 28th February, 1894, I noticed a number of boxes of small plaice in the Grimsby market, and was informed that they had been consigned thither by cargo steamer from Hamburg.

It was at once apparent that they differed in some respects from the small plaice landed by our own fishing-boats, as also from any that I had hitherto examined among consignments which reach this port from time to time from Continental sources. It was evident, in fact, that, although very small, they were nearly all sexually mature, and actually ripe.

I selected what appeared to be a representative series for closer examination at the Cleethorpes Laboratory, and found that the smallest ripe female measured only 9½ inches in total length, whilst the largest fish of the lot, also a ripe female, was only 13½ inches long. My selection, having been made mainly with a view to inquiry as to size in relation to sexual maturity in the more important sex, consisted almost entirely of females.

With the exception of the coloration, which was in some individuals rather unusual, I could detect no character in which these fish differed to an appreciable extent from the North Sea examples with which I am familiar, but from the presence in the same consignment of a number of unusually spinous flounders (*P. flesus*, Gottsche) I formed the idea that they must have been caught in some locality to which our own vessels never penetrate.

I need hardly say that, in view of the opinion I have expressed in this Journal and elsewhere as to the large size at which North Sea plaice first begin to spawn, the occurrence of such small mature examples (possibly from a North Sea ground) came as rather a shock to me.

Therefore when, through the courtesy of Mr. G. H. Mudd, I had been put into communication with the consigners, I was greatly relieved to find that the fish were actually caught in the Baltic, and not in the North Sea at all.

Since it appeared to be within the bounds of possibility that the very unusual weather of last summer might have had some effect in accelerating the maturation of the sexual organs in young fish, I had in the meantime examined a number of small plaice which were being brought into the market from the usual sources (including a large number landed by a German steam-trawler from the Horn Reef), but found the conditions to be precisely similar to those which I had noted and recorded in previous years.

The Hamburg merchant from whom I derived my information as to the origin of the small spawning fish also tells me that they never grow to a large size and are sometimes called "Golden butts." Now "Goldbutt" is the vernacular name which Gottsche found to be applied to what he considered the most typical examples of *Pl. platessa*, Linn. He describes two varieties, *Pl. borealis* and *Pl. pseudoflesus*.*

The points in which the latter variety differs from the type (of Gottsche) are indicated as the presence of ciliated scales on the ocular side (on the sides of the head and of the abdomen, along the lateral line, and along the bases of the dorsal and anal fins), and the small number of the dorsal and anal rays. This variety, in which, as is implied by the description given by Smitt,† the blind side may also be to some extent ciliated, is stated by that writer to be identical with Nilsson's var. *baltica*, and to be commonest in the Sound and the Baltic. I do not find that Gottsche expressly mentions that it has been taken in the North Sea, since its occurrence in Hamburg market is no proof of this. Kroyer, however, has recorded it from Hästholm.‡ Gottsche noted that "gold butt" first appeared in the Hamburg market in winter, and only rarely. At Copenhagen they were in the market the whole of summer. Most were taken in Oresund. *Pl. pseudoflesus* are simply stated to have been taken in company with "gold butt."

I had considered it very probable that *Pl. pseudoflesus* occurred amongst the small plaice which are constantly landed at Grimsby during the spring and summer from the opposite coast of the North Sea, but had never succeeded in finding any, nor, among the first lot which I obtained from the Baltic, could I find any trace of ciliation. As I have already remarked, those which I examined were nearly all females, a point worthy of note in this connection. The number of fin-rays, however, presented some approach to the formula given by Gottsche, but the variation was in excess of that therein indicated, since some of the specimens had as many rays as a typical North Sea plaice.

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* Wiegm. Arch., 1835, p. 143.

† Hist. Skand. Fish., ed. 2, 1893, i, p. 393.

‡ *Teste* Smitt, loc. cit.

Two other consignments of small Baltic plaice were received at Grimsby a little later, and I again examined a number of specimens. In one consignment I found a single fish with very well-marked ciliation, but the rest of those which I handled appeared in the somewhat dim light of the fish market to be quite smooth. In the third consignment a box proved to contain nearly equal numbers of ciliate and smooth examples. The ciliation was present in different degrees, so that there was an absolute continuity in the series from the perfectly smooth to the fully ciliate condition.

In those examples in which the ciliation is most strongly marked, the scales on the head and interspinous regions of the ocular side have the free margin produced into from two to four distinct spines, which are outwardly directed, so as to project vertically to the surface of the body. The scales of the median region of the body are only feebly or not at all ciliate, the spines when present being more numerous than those in the regions previously referred to, but much smaller and not outwardly directed. The scales on the ocular sides of the fin-rays are also feebly ciliate.

On the blind side the ciliation is much less marked, and is altogether absent from the scales on the prominent parts. The scales on both sides exhibit a certain degree of imbrication, but not more than may be observed in young examples of ordinary North Sea plaice, the non-imbrication of the scales in this species being a character only entirely applicable, at best, to large examples.

The proportions of the small Baltic fish, whether ciliate or smooth, are of no service in distinguishing them from ordinary plaice, but some of the ciliate examples are rather strikingly coloured.

The following notes were taken from the fresh condition :—Ocular side reddish brown, with a number of orange spots. Of these the larger are irregular in shape, and surrounded by a narrow pale "halo," while each scale in the orange part is outlined with dark brown. The largest spot, in an individual 10 inches long, measured $\frac{7}{16}$ by $\frac{3}{8}$ inch. These spots occur chiefly on the dorsal half of the body, viz. along the interneural ridge, and dorsal to the lateral line. The smaller orange spots are also most numerous on the dorsal half. A number of dark brown or blackish spots, some interspersed with a little orange, occur chiefly on the ventral half. Rows of large blackish patches, some with an orange centre, occur along the dorsal and anal fins, and some small dark markings are present on the caudal fin. The blind side has the semi-translucent whiteness characteristic of normally coloured plaice.

Most of the smooth examples which I examined had only small pale orange spots, rather few in number and remote from each other. Such was also the case in only slightly ciliate examples, but both series showed intermediate degrees of coloration, rendering it impossible to draw any absolute distinction based on colour alone.

While dealing with the coloration it is worthy of remark that amongst a number of flounders (*Pl. flesus*) present in the consignments of small plaice, some were pigmented in very much the same way as the most ciliate of the plaice, but had no dark pigment, while the blind side was dead white. Other flounders in the same consignment were uniform brown or blackish brown (on the ocular side).

The flounders were very much more spinous than any which I have seen from our own coasts, practically the whole of the ocular surface being in some cases covered with rough tubercles, which were also present to a considerable degree on the blind side. According to Smitt (op. cit., p. 397) Scandinavian flounders appear to be also more spinous than our own, in which the tubercles, according to my experience, are confined to the lateral line and the bases of the dorsal and anal fins. On examining examples from the Atlantic coast of Denmark I find some in which the spinulation is rather in excess of that exhibited by British specimens, a condition which might be expected from the intermediate position of the locality.

To return to the Baltic plaice, I handed over a series of ciliate and non-ciliate examples to Dr. Günther, who suggested that the ciliate ones were the males. I know of no observations which support such an opinion, but, on examining those which I had reserved for my own use, I find that it appears to be correct.

I append a list of the fish examined for this purpose.

	Inches long.			
A.	$12\frac{1}{4}$	Smooth; female; mature	D. 75	A. 55
B.	$11\frac{3}{8}$	„ „ „	„ 72	„ 51
C.	$10\frac{5}{8}$	„ „ „	„ 67	„ 54
D.	10	„ male; immature	„ 75	„ 55
E.	12	Head feebly ciliate; female; mature	„ 68	„ 53
F.	9	Head and interspinous regions ciliate; male; mature	„ 67	„ 51
G.	$9\frac{3}{4}$	„ „ „ „ „	„ 69	„ 52
H.	$8\frac{3}{8}$	Ciliation extending a little on to trunk „ „	„ 72	„ 52
J.	$9\frac{3}{8}$	Intermediate between H and L „ „	„ 64	„ 48
K.	$9\frac{3}{8}$	„ „ „ „	„ 70	„ 54
L.	$11\frac{1}{2}$	Everywhere ciliate except in immediate neighbourhood of pectoral; male; mature	„ 72	„ 54

The details of ciliation given above refer to the ocular side.

In ten other non-ciliate examples, all or nearly all females, the fin-ray formula was D. 63—74, A. 47—55. The formula of all which I have examined is therefore D. 63—75, A. 47—55, and it is evident from the condition in those separately enumerated that the formula shows no grounds for suggesting a distinction, other than sexual, between the ciliate and smooth examples. I have omitted to transcribe the proportions, as they differ in no degree inexplicable as individual variation.

The inferences which appear to be permissible from the details enumerated above are as follows:—(1) The female, in these dwarf Baltic plaice, is either smooth, or ciliated only on the head. (2) The male is almost always more or less ciliate; perhaps always ciliate when mature, the ciliation increasing with the growth of the fish.

I may add that none of my examples show the ciliation especially conspicuous along the lateral line, though this has been given as a character of *Pl. pseudoflesus.*

It would appear, then, that the variety last named is merely the male of what Gottsche considered to be the typical form of *Pl. platessa, i.e.* the "gold butt." The "scholle," the variety *Pl. borealis* of the same author, appears to be the ordinary North Sea plaice.

Apart from these Baltic fish, I have met with instances of ciliation in two other examples of the plaice. The first was a mature male, 19$\frac{3}{8}$ inches in length, taken in April of the present year on the Great Fisher Bank. In colour and general appearance it resembles a number of normal examples taken at the same time, but the scales on the ocular side have about 8 to 10 very short pectinations in the central region of the posterior edge. On the blind side the scales are either smooth or only very feebly ciliate.

The other example is a male from Iceland, 24$\frac{1}{2}$ inches long. The ciliation of the ocular side is much the same as in the Fisher Bank specimen, but the scales of the blind side are smooth. In both examples the scales of the caudal region imbricate to some extent, but not more than in smooth fish from the same locality, and the ciliation is by no means confined to this region of the body.

There is good reason to believe that there is a regular migration of plaice between the Fisher Bank and the north-west coast of Denmark (and probably also the Sound), and that, in fact, the Fisher Bank plaice are reared on the Danish coast. It is not, therefore, surprising that ciliate examples should be met with both on the Fisher Bank and at Hästholm.

It seems probable enough that the characters of ciliation and size would be found to vary in a degree corresponding to the locality if a series could be obtained from the different parts of Denmark, from the Baltic to the southern region of the North Sea coast. No such material, however, is available, and all that can be said, in view of observations recorded above, is that the diagnosis of *Pl. platessa* must be so amended as to allow for the occurrence of ciliated scales, especially in males.

Judging by the analogy of fresh-water fish (*e.g. Salmo*, &c.), it seems quite possible that fish which reach a large size in the North Sea might remain permanently stunted if confined to the Baltic. On such an hypothesis one might regard the small mature Baltic plaice as distinct in nothing, save environment, from their larger brethren in the North Sea. The very general ciliation of the males in the former, and the rarity of this character in the latter seems, however, to show that a more important distinction exists, and that the small fish are a true variety, indistinct enough, no doubt, if specimens from intermediate localities could be procured. Living ova, which I took from some of the specimens described above, measured from 1·706 to 1·796 mm. in the unfertilized condition, dimensions which overlap the extremes recorded for the ova of Atlantic plaice, but which nevertheless yield a considerably less mean diameter. That the Baltic herring are considerably smaller than the North Sea and Atlantic representatives of the same species is well known, and it would appear that the difference in size is apparent from the earliest stages, since the former, when newly hatched, are only 5·2 to 5·3 mm. long (Kupffer), and therefore about 2 mm. shorter than such newly hatched North Sea larvæ as have come under my own notice (Ann. Mag. Nat. Hist., 1889, p. 369).

On the other hand, the flounders which I found amongst the consignment of Baltic plaice were fully as large as those met with on our own coasts, and it is a significant fact that the flounder is a fish which flourishes best in brackish or even in nearly fresh water. The low specific gravity of the Baltic water is familiar to everybody, as is also the fact that its existing fauna differs, in the absence of certain marine organisms, from that of the open sea. Hence it is very interesting to note that these small plaice appear to reach a limit of size (about 13½ inches) which practically corresponds to the size which is attained by a young North Sea plaice before it leaves such an estuary as the Humber for the offshore grounds. It is, no doubt, the quest of food suitable to its increasing needs that causes the emigration of the young North Sea fish, and even without special knowledge of the food-supply in the Baltic, it is perhaps permissible to assume that it is the inadequacy of the food that limits the growth of the goldbutt. It is restricted, in fact, to a permanently estuarine condition.

The question of dermal armature in relation to environment is much more difficult, and I am not at present prepared to attack it; I may say, however, that materials which I have been accumulating point to some conclusion in which the theory of protection has no very obvious place.

VIII. On some Specimens of *Molva abyssorum*, Nilss., from Iceland and Faroe.

The present note is a brief abstract of a paper read before the Zoological Society in May of the present year. The species was previously known only from the coast of Scandinavia, where it occurs chiefly at depths exceeding 100 fathoms, and appears to be known as the Birkelonge, or "Trade Ling." I was able to show that it occurs regularly, if in rather small numbers, on the lining grounds off Faroe, and has also been taken, both by line and trawl, on the south coast of Iceland.

The species may be described as differing from the common ling (*M. vulgaris*, Flem.) chiefly in characters which, in Gadoid fishes, have been found to be indifferently associated with either an abysmal or a boreal habitat. Thus the maximum size reached is smaller, the eye larger, the fin-rays more numerous, the body more slender and elongate, and the caudal peduncle very much more slender than in the common ling. The visceral anatomy shows very well marked characters; the liver is very large, and the walls of the alimentary canal extremely delicate—so much so, in fact, that it is difficult to lift the intestine, even in fresh specimens, without rupturing it. Besides being more delicate, the intestine is also much shorter than that of the common ling, while the stomach is much larger. The comparative shortness of the intestine has been noted by Günther in the case of a deep-sea member of the Percidæ, and a reduction in the thickness of the walls of this structure appears to be strictly comparable to the reduction noticeable in the bones and muscles of deep-sea fish generally.

The air-bladders of the two species of ling do not differ materially, but the kidney of the deep-sea fish is less swollen in its posterior region than that of *M. vulgaris*. Moreover the so-called head-kidney in *M. abyssorum* is more definite in outline than the corresponding structure in the common ling, and was found to be typically reniform in structure and obviously functional. The head-kidney of the common ling, however, contains a certain amount of reniform matter, and cannot be regarded as wholly functionless.

At the time my remarks were written, the only figure of *M. abyssorum* which I was able to discover was a small outline drawing given by Ström (Sond. Beskriv.), and I had therefore appended a larger and more detailed figure, adding another of the common species for purposes of comparison. However, before my paper was communicated to the Society, the appearance of Smith's edition of the History of Scandinavian Fishes (Lond., 1893) supplied coloured illustrations of both species. The figure of *M. abyssorum* differs from my own specimens, and from the descriptions given by other authors, in that the upper jaw is shown as longer than the lower. In all my own specimens, seven in number, the lower jaw projects distinctly, but Smith states that the contrary was the case in those which had come under his notice. They appear to have been of rather smaller size, and there is an indication in my own series that the relative length of the lower jaw increases with the growth of the fish. This is well known to occur in *Gadus virens,* in which the relative lengths of the jaws in the young are completely reversed in the adults, but I do not think it can occur to anything like the same extent in the species under discussion.

My paper, besides dealing at length with the points referred to above, gives detailed measurements of all the specimens, and discusses the relative antiquity of the two species. My conclusion that *M. abyssorum* is a specialised offshoot from a form not greatly differing from the common ling of the present day is exactly opposite to that arrived at by Prof. Smith, who holds *M. abyssorum* to be " essentially the predecessor " of the other. To me it appears impossible to accept this view without also regarding the typically abysmal Gadoids as more primitive than the littoral forms, and such an inference seems wholly unsupported by the interpretation which the present state of our ignorance permits of the evidence of the subject.

Young Stages of Zeugopterus punctatus.

By

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Naturalist to the Association.

On May 4th of the current year a number of small Pleuronectids were captured by the hand in a pool left by the ebb tide at Plymouth Breakwater, and brought to me alive. Two of them were very transparent, and, from their habit of lying on the right side when at rest, evidently sinistral forms. One of them was almost perfectly symmetrical; while in the other the torsion of the facial region and eyes had commenced. The pigmentation had the form of interrupted transverse bands, which were most conspicuous on the dorsal and ventral fins; on the dorsal fin seven bands were indicated. The terminal portion of the original trunk, containing the notochord, was seen at the upper edge of the caudal fin. The neurochord was covered with pigment, forming a very distinct band, situated, however, not in the skin, but in the connective tissue surrounding the neurochord or spinal cord. The mouth was large, and the snout upturned. The pectoral fin was large, the pelvic small. But the most important characteristic was the presence of two straight spines projecting laterally from the auditory region. These have been called otocystic spines by Prof. McIntosh, but I think they would be more appropriately described as periotic spines, as they are evidently projections of the periotic cartilage or bone; to which particular bones of the periotic region they belong has not been determined. Mr. Holt cut sections of the spines *in situ*, and found that they consisted of a knob of periotic cartilage passing into a mass of undifferentiated cells, the whole forming the core of a dermal spine consisting of hyaline ossified tissue. In my specimens I observed a third spine, much smaller, situated in the region of the frontal bone, behind and above the eye; it was visible in both the stages.

The numbers of the fin-rays were D. 90, A. 69, in one specimen, which was kept alive for a few days and preserved when the right eye had reached the dorsal edge of the head. The younger specimen was 11 mm. in length; the other, after being preserved and mounted, is 10 mm., a diminution which may be due to the process of preservation, or partly perhaps to the advance in metamorphosis, a reduction of size during the transformation having been observed by me in the flounder.

A sinistral Pleuronectid having these periotic spines was described and figured by McIntosh and Prince (Trans. Roy. Soc. Edinb., vol. xxxv, pl. iii, 1890, p. 846) as a stage in the history of the turbot. The specimen was 9·8 mm. long, and another specimen a few mm. longer, having similar spines, is mentioned. The mention of the spines alone seems to indicate that these specimens were either of the same species as the specimens obtained by me, or a closely allied form. The figure given, probably drawn from a spirit specimen, is not perfectly characteristic.

A discussion of the identification of the larva with otocystic spines is given by Prof. McIntosh in the Tenth Report of the Fishery Board for Scotland, p. 279. He refers to Mr. Holt's opinion, that it belongs to the brill, and mentions another specimen, taken on Smith Bank off Caithness, in which the dorsal had 87 and the anal 62 rays.

In the Eleventh Report, published in 1893, Prof. McIntosh makes a further contribution to the question of larval sinistral Pleuronectids. He mentions no new specimens of the form here under consideration, but gives his reasons for concluding that the young specimens shown in pl. xiv, figs. 7, 10, and 11 of the Tenth Report, belong to *Zeugopterus punctatus*: these were 4·5 to 9 mm. in length. He also thinks it possible that the form with periotic spines may be a later stage of the same species, the diminution in the size of the eye being due to changes accompanying growth, or to abnormality. With this opinion I cannot agree. The form without the spines has larger eyes, and has the eye on the edge of the head when only 9·5 mm. long; it is, I think, a distinct species.

It is somewhat difficult to follow the successive discussions in which Prof. McIntosh has described and compared his specimens of young sinistral forms, more particularly as his figures are, as a rule, inadequately characteristic, often having been delineated from dead and imperfectly preserved specimens. Mr. Holt has been able to give a more comprehensive and more completely illustrated description of specimens of similar characters procured in the survey of the west coast of Ireland in 1890 and 1891. His results were published last year in the Scientific Transactions of the Royal Dublin Society, vol. v, ser. 3. The form with periotic spines (if it is a single species and not more than one) is represented in Mr. Holt's collection

(Species XIV in the memoir) by a number of specimens 5·87 to 10·62 mm. in length. The characteristic spines were present even in the smallest specimens, a fact sufficient to disprove Prof. McIntosh's supposition that the spines are developed only at the later stages. Mr. Holt figures two stages, one perfectly symmetrical, 7 mm. in length, having no fin-rays except the first indications of the caudal, but having the characteristic transverse imperfect bands of pigment. The other figure shows a stage 10·62 mm. long, in which the fin-rays of the dorsal and ventral fins are developed. This stage, however, is younger than those I have described, the termination of the original body or opisthure not being so much reduced as in my specimens, and not distinctly marked off from the dorsal and ventral fins. The number of fin-rays in Mr. Holt's specimen was D. 80 ca, A. 66 ca; it was not possible to count the exact number.

Mr. Holt considers, and I agree with him, that this form cannot belong to *Arnoglossus megastoma,* nor to *A. laterna,* of which he has identified young specimens 19 mm. and 25 mm. in length respectively. The eyes are relatively much larger in *A. megastoma,* and the young *A. laterna* seems to have less pigment. He concludes that the parent form is either *Rhombus lævis,* the brill, or *Zeugopterus norvegicus,* the Norway topknot. Now, in my own opinion the suggestion of the brill is out of the question for several reasons, one of which is that in my specimen the fin-rays are D. 90, A. 69, while the maxima in the brill according to Day are D. 85, A. 63. The symmetrical stage of the brill figured by Raffaele, and nearly 8 mm. long, is of a different shape, and much more opaque and pigmented.

With regard to *Z. norvegicus,* Günther (Proc. Roy. Soc. Edin., No. 127, p. 217) gives the fin-rays as D. 80, A. 66, and I have counted D. 84 in one of my specimens, so that there is no evidence that the number reaches as high as in my young form.

The remaining sinistral forms to be considered are the turbot, *R. maximus,* whose young are known, and not identical with the present form; and the other two topknots, *Z. punctatus* and *unimaculatus.* The fin-rays of the latter, according to Day, are D. 70 to 80, A. 61 to 68. *Z. punctatus,* on the other hand, according to the same authority, has D. 87 to 101, A. 69 to 80, so that there is strong probability that this is the parent form we are seeking. This conclusion is supported by the shape of the outline of the fins in the larval specimens, the posterior part of the fish approaching a rectangular shape, as in the adult *Z. punctatus,* and by the comparison of the shape of the snout in the latter and the young form. The snout in the adult is very much shortened as compared with the young, but it exhibits, apart from the anterior part of the dorsal fin which is attached to it, a deep depression at the edge between the cranium and the extremity of the upper jaw; and further, the end of the upper jaw is broad and truncated in a manner which resembles the character of the young form as seen in my specimens. My conclusion as to the identification of the form with periotic spines agrees with that of Prof. McIntosh, but I differ from him in not including the series of smaller forms without the spines.

Experiments on the Rearing of Fish Larvæ in the Season of 1894.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

It may be useful to put on record the following notes of renewed attempts to solve the difficult problem of rearing fish larvæ.

On January 23rd a large number of eggs were observed in one of the aquarium tanks which contained several whiting. The eggs were collected and placed in a hatching jar, and began to hatch on January 29th. I prepared a small tank in the Laboratory for rearing the larva. The outflow pipe was protected by placing over it an inverted hatching-jar, open at both ends and resting on a layer of sand and gravel. The water was supplied to the tank by a solid carbon block filter attached to one of the jets. The inflow of water was very slow indeed. The temperature in the tank on February 3rd was 12° C., and on this date the larvæ in the tank were healthy, having the jaws developed, but the yolk not yet all absorbed. One lot of larvæ were put into the tank on January 30th, a second lot on February 1st. On February 4th I put in some fine particles of worm food, that is to say, ovarian eggs of Nereis obtained by mincing the worms and then separating the eggs by decantation. On the 5th, as the larvæ did not seem to take the worm-food readily, I put in some tow-net collections strained through fine bolting cloth so as to exclude the larger animals. Then I saw the larvæ pecking at this food, and in one I took out I found (in the stomach) a Gasteropod larva with spiral shell. On the 6th I put in a little of both kinds of food, and observed that the larvæ preferred the pelagic material, but they did not feed vigorously on either kind. On the 7th I examined a few, and found the stomachs of most of them empty and dilated, but in one was a small Copepod. On the 8th the number of the larvæ was diminished; on the 9th very few were to be seen, and on the 10th none were found. In the course of this experiment I found that when the supply of water was very much reduced on account of the choking of the charcoal filter a scum of bacteria in the zooglœa form soon appeared on the surface. I therefore replaced the charcoal filter by sand filters made in a box or bottle, during the whole experiment supplying water only through some kind of effective filter.

On March 10th flounder and plaice eggs were first seen at the surface of the large tank, containing flat-fishes, in the aquarium. On the 12th I collected a considerable number and put them in a hatching jar, and shortly afterwards placed others in a second hatching jar. It was not practicable to separate the larger plaice eggs from the smaller ones of the flounder. On the 19th the flounder eggs were found to be hatched; the plaice larvæ began to emerge on the 22nd, and on the 24th I turned all the larvæ out into one of the Laboratory tanks, the inflow of water passing through a filter of sand and gravel contained in a glass jar. I fed them as usual, partly with eggs of Nereis, partly with strained material from the tow-nets. On the same day I put some of the larvæ into a bell-jar filled with water brought in from the open sea. In the tank, in addition to the inflow of water I arranged a delivery of air in small bubbles at the bottom of the tank, thinking that this would serve two purposes, to aërate the water and to keep the food-particles suspended.

The plaice larvæ lost the yolk and began to feed on March 27th. They took the worm food more readily than the living material from the tow-nets. On April 2nd they were nine days old, and at this time the very fine primordial rays had appeared in the posterior part of the larval median fin membrane. On April 9th there were not many surviving, and in these no great advance in development was visible, but the commencement of the formation of the permanent caudal fin was indicated. The number steadily diminished, and the last specimen was seen on April 23rd, when it was thirty days old. In these older specimens the formation of the permanent fin-rays had not commenced, still less had the rotation of the eyes begun to take place.

The larvæ in the bell-jar in water from the open sea lived a much shorter time; the last was seen on April 1st.

Another lot of plaice larvæ were hatched on April 9th, and I turned them out into one of the Laboratory tanks supplied with water directly from a jet without filtration, and I provided no air supply. I fed these very carefully on the usual worm food, which they took readily. I carefully washed the food, so as to keep out as much as possible the blood and soluble matters derived from the worms. These larvæ began to die off as usual after some days, but two were seen alive on May 16th, when they were thirty-seven days old, or five weeks and two days, which is a much longer period than I have succeeded in keeping them before.

Nerve Elements of the Embryonic Lobster.

By

Edgar J. Allen, B.Sc.Lond.

After repeated trials with dilute solutions of methylene blue upon larvæ and embryos of a number of the smaller decapod crustacea, a favourable object for the study of the nervous system was at last found in the embryo of the common lobster. The embryos of this animal are specially advantageous on account of their large size, which enables them to be readily manipulated without much damage being done to their tissues, and also on account of the large size of the individual nerve elements.

In order to expose the ganglionic cord in the thorax, it is only necessary to break the yolk with needles and carefully remove it. If the embryo thus prepared be placed with the dorsal surface of the cord uppermost in a dilute solution of methylene blue in sea water (1 : 50,000 or 1 : 100,000), staining of one or more nerve elements takes place.

By practising this method upon a large number of embryos at various stages of development, staining of the following elements has been obtained :

1. Elements starting from cells in the brain or anterior thoracic ganglia, and giving off fibres which can be traced throughout the length of the ganglionic cord to the sixth abdominal ganglion. The fibres of some of these elements pass down the cord upon the same side as that on which the cell is situated, whilst others decussate and pass down upon the opposite side. Many of the fibres give off collateral branches to the neuropile of each ganglion through which they pass. One pair of fibres belonging to this group are the so-called giant fibres. They possess a diameter many times greater than any other fibre in the cord, and start from a cell which lies on the ventral surface of the brain. In the sixth abdominal ganglion these fibres break up into a number of smaller branches.

2. Elements originating in a cell in one of the ganglia of the cord, from which a fibre is given off, which after decussation with its

fellow of the opposite side runs forwards along the cord, and can be traced to the anterior part of the brain, where it ends by breaking up into fine branches.

3. Elements starting from a cell in one ganglion and giving off a fibre which, after sending a number of arborescent branches to the neuropile of that ganglion, ends in a small tuft of fine branches in the ganglion next behind.

4. Elements starting from a cell in one ganglion giving off a fibre which sends out lateral branches to the neuropile of the ganglion, passes forwards to the next ganglion, where it gives off a lateral tuft of branches, and ends also in a tuft of branches in the next ganglion, but one in front of that in which the cell lay. The terminal tuft lies close to the lateral tuft of the element of the next ganglion, and directly opposite the terminal tuft of an element of group 3.

5. Elements starting from a cell in a ganglion, giving off a fibre, which passes through one of the lateral nerves of the cord, and finally breaks up upon a muscle. A considerable number of elements of this type can be distinguished, and these are repeated in successive ganglia. They must be regarded as motor elements.

6. Elements originating in a cell which lies in the dorsal ectoderm of the abdomen—therefore entirely outside the ganglionic cord,—and gives off a fibre which eventually enters one of the abdominal ganglia, where it bifurcates, sending one branch forwards towards the brain, whilst the other passes backwards through the posterior ganglia. These elements are probably sensory in nature.

A full account of these observations, with figures, has appeared in the Quarterly Journal of Microscopical Science.

Faunistic Notes at Plymouth during 1893-4.

With Observations on the Breeding Seasons of Marine Animals, and on the Periodic Changes of the Floating Fauna.

By

Walter Garstang, M.A.,
Fellow and Lecturer of Lincoln College, Oxford; late Naturalist to the Marine Biological Association.

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The year 1893 was one of exceptional interest to the marine zoologist. During the first two months Plymouth experienced a continuous succession of heavy gales, but towards the middle of March the winds became lighter, and the sea, which had been running remarkably high outside the breakwater, subsided. From that time onwards till the middle of September we enjoyed six months of the most delightful weather,—a period, with scarcely a break, of calm seas and almost cloudless skies. Under the influence of the great heat the temperature of the Channel waters rose continuously, until in August it had attained a point unprecedented for quarter of a century; and it was of the highest interest to observe the effect of this high temperature, and of the prolonged calmness of the sea, upon the floating population of the neighbouring portion of the Channel. Numbers of semi-oceanic forms which rarely reach our shores arrived in remarkable profusion. In June the tow-nets were crowded with Salps, while towards the latter end of August they were almost choked by masses of living Radiolaria.

Even the bottom fauna was influenced, as was shown by the extraordinary abundance in the Sound thoughout the spring and summer of the Tectibranch *Philine aperta*. *Oscanius membranaceus* also, though to a less extent, was unusually plentiful, penetrating even some distance up the Hamoaze.

Another phenomenon which is probable referable to the same cause, although in a somewhat different manner, is the relatively greater abundance this year (1894) of many of the regular constituents of the bottom fauna. For example, the Hydroids *Tubularia indivisa* and a smaller form which appears to be *Tubularia humilis*, together with *Coryne pusilla* and *Eudendrium ramosum*, have been taken in the Sound this year in unusual quantity. The same remark applies to many Nudibranchs, and especially to the Æolid *Facelina coronata*,* which has been remarkably common this year at Plymouth. I do not doubt that the unusual abundance of these and other forms may be directly attributed to the very favorable physical conditions under which the reproduction of their species took place in the preceding year. The destruction of larval life by physical agencies must then have been considerably less than the normal rate. Indeed, in the case of the oyster, as was attested by Prof. Herdman in a letter to Nature (July, 1893, p. 269), there was undoubtedly an unusually heavy fall of spat on the west coast of France last year, which implies that an unusually large percentage of larvæ were enabled to attach themselves and to pass safely through the critical stages of their metamorphosis; and also, perhaps, that the reproductive activities themselves were rather above the normal.

So much for the general aspects of the fauna during the past eighteen months. Additional facts bearing out the above remarks may be gathered from the body of this paper.

In the three succeeding sections are given—firstly, a list of the principal captures and additions to the fauna made since my last† communication to this journal up to May 30th, 1894, when I left Plymouth; secondly, some observations on the breeding seasons of marine animals at Plymouth; and thirdly, some remarks on the periodic changes in the constitution of the floating fauna.

In several respects, however, I have to regret the incompleteness of my notes. They are compiled directly from my diaries, and are written on foreign soil, where I am without access to some of the appropriate works of reference and to several of my manuscripts. On this account the last two sections especially of this paper are offered simply as preliminary communications upon the interesting subjects of which they treat; I shall endeavour to expand them both in scope and detail when further observations have been made and the time is ripe.

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* I showed some years ago that the smaller Nudibranchs are annuals, and require only a year to attain their full growth. The same thing is true of Hydroids and many other Invertebrates (this Journal, 1890, p. 450).

† *Notes on the Marine Invertebrate Fauna of Plymouth* for 1892, vol. ii, 1892, pp. 333 to 339.

ROSCOFF; *June* 30*th*, 1894.

I. FAUNISTIC RECORDS.

HYDROZOA.—Several additional colonies of *Tubiclava cornucopiæ* have been obtained in 15 to 25 fathoms of water south of the Mewstone. In all cases they were growing, like our first specimen, on shells of *Aporrhaïs* or *Turritella,* tenanted by the Gephyrean *Phoscolion strombi.* Some of the colonies were young, and possessed a reticulate stolon, like Norman's original specimens from the Shetlands—thus confirming my anticipation that the solid carpet-like base of large colonies is not a specific difference, but a senile character (Trans. Devon. Assoc., 1892, pp. 378–9).

Clava cornea (of Hincks) is abundant on the fronds of Fucus growing in that branch of the Hamoaze known as the Lynher, or St. German's River.

In tide-pools under the Hoe two species of *Clava* are common, one being *C. multicornis,* and the other a larger and stouter form, which seems to be the *Clava leptostyla* of Hincks's monograph. To prevent confusion, however—since one of the characteristics of our form, at any rate, the purple colour of the gonophores, is nowhere mentioned,—I give its leading features here.—Colonies clustered, attached to stems of algæ and to the floor of limestone pools; polyps very large and stout, tall when extended, of a rich salmon-flesh colour; digestive cavity having a distinctly spiral marking, or even coiled appearance, which is seen when the polyps are fully extended as well as when contracted; gonophores in two, three, four, or rarely five large compact round bunches immediately beneath the tentacles, and of a conspicuous purple colour when mature.

Tubularia indivisa has been dredged occasionally in Millbay Channel. Good colonies were obtained there on April 13th, 1894, but the gonophores were provided with very short stalks, and did not form pendulous racemes. With them were large colonies also of *Tubularia larynx,* crowded with gonophores. On March 9th a small colony of a *Tubularia* was dredged in Barn Pool, growing on some Ceramium or Polysiphonia attached to a root of Laminaria. The stems were without annuli, the tentacles were white, and there was a collar-like expansion below the hydranths, and I inferred the species to be the *T. humilis* of Hincks's monograph. On the 19th, however, I collected some other colonies from tide-pools below the Hoe, and they resembled the preceding in almost all points except in the absence of a collar. The polypites were white, the stems entirely destitute of annulations or corrugations, and white. The colonies were crowded with gonophores, which each exhibited a red patch. I scarcely doubt that these two forms belong to the same species.

Coryne pusilla has been common in tide-pools below the Hoe, side by side with *Clava multicornis* and *Tubularia humilis;* also on the breakwater, and at Cremyll below the garden battery. Intermediate varieties between the *Coryne pusilla* and *C. fruticosa* of Hincks are common. On July 17th, 1893, I found an extensive colony of another *Coryne* attached to a root of Laminaria trawled in the Sound. The stems were slender, branched, and irregularly annulated; the polyps red, much elongated, and provided with fifteen to eighteen tentacles, scattered or irregularly whorled. The colony attained a maximum height of 1½ inches, but was for the most part less than this, and of lax growth. It is undoubtedly allied to Hincks's *C. vermicularis,* and I record it as such; but it should be noted that the colony was certainly not dense, and the tentacles were apparently less numerous than in Hincks's type. As our colony was without gonophores, however, it is possible that these differences may have been due to immaturity.

Eudendrium ramosum has been frequently dredged on the New Grounds and in Millbay Channel.

Garveia nutans was dredged in Millbay Channel several times during April and May, 1894. It is interesting to notice that while this species is common between tide-marks at Hilbre Island at the mouth of the Dee, at Plymouth it is rare, and lives in deep water only (15 to 20 fathoms).

Another Gymnoblast which I found plentiful on certain stones at Cremyll presents several remarkable features which will justify a separate description: it is now under examination.

During the latter half of February and March, 1893, the tow-nets contained numerous specimens of the Anthomedusa *Rathkea octopunctata,* which is the *Lizzia octopunctata* of Forbes' "Naked-eyed Medusæ," and the *Cytæis octopunctata* of M. Sars. Haeckel has made a mistake in treating these as different forms, and in assigning them to different genera, viz. to *Margellium* and *Rathkea* respectively. In Haeckel's system (System der Medusen, pp. 95 and 97) each of these types possesses eight bundles of tentacles, but in *Rathkea* the bundles are perfectly similar to one another, while in *Margellium* the four perradial bundles contain a greater number of tentacles than the four interradial. The mature *Rathkea* (= *Cytæis*) *octopunctata* of Sars and Haeckel is characterised by having three tentacles to each bundle; but since Sars has shown that the interradials develop later than the perradials, and that the lateral tentacles of each bundle develop later than the median tentacle, a stage is consequently passed through in which the perradial bundles consist of three tentacles and the interradials of only one. On the other hand, *Margellium octopunctatum* is defined by Haeckel as possessing perradial bundles of three tentacles and interradials of two tentacles—apparently on the sole basis of Forbes' figure (loc. cit., pl. xii, fig. 3). In this definition Haeckel has disregarded Forbes' statement that the number of tentacles in the interradial bundles is "either two or three, . . . the number varying in different specimens" (loc. cit., p. 65), and I am able to confirm Forbes fully in this respect. The development of the lateral tentacles in the interradial bundles takes place very irregularly. In some instances I have seen them arising together, one on each side of the median tentacle, and growing at a uniform rate; but in the majority of cases there is an irregularity in the time of their origin, and one of the lateral tentacles may have become considerably developed before the rudiment of the other has appeared. It thus very often happens that individuals may be seen to possess interradial bundles of two tentacles only, and it is this condition which Forbes has figured. It is, however, as I have just shown, simply an instance of temporary asymmetry due to inequality of growth. The species *Margellium octopunctatum* of Haeckel has consequently no existence. The oral tentacles (*Mundgriffel*) of our own specimens show a single bifurcation only (cf. Giard, Bull. Sci. France et Belgique, xix, 1888, pp. 317, 318, pl. xxi), whereas Haeckel gives "Mundgriffel 3—4 mal dichotomisch getheilt" as one of the characteristics of his species,—upon what grounds I do not know. The buds, so characteristic of this medusa, form a longitudinal row on each of the four sides of the manubrium, each row containing from two to four buds, which increase regularly in size from the oral to the umbrellar region of the manubrium. I have not detected the spiral arrangement attested by Giard, although his remarks on the order of their development apply equally well to the specimens I have examined. The medusa was taken in the tow-nets in February and March of this year also, but not in the same abundance as last year. It was succeeded towards the end of April by other Margelid medusæ, *Bougainvillea* (*Margelis*), both *principis* and *ramosa* of Haeckel, which seem, indeed, to form only one species.

Other Anthomedusæ that have been taken are *Corymorpha nutans*, which was abundant in May this year; *Sarsia prolifera* and *tubulosa* (rarely), *Podocoryne* (*Dysmorphosa*) *carnea*, *Tiara octona*, *Amphinema Titania* (= *Saphenia dinema* of Forbes), and *Amphicodon amphipleurus* of Haeckel. The last-mentioned very remarkable medusa had numerous buds arising from the tentacle bundle; it was taken on a few occasions only during April of this year.

Among Calyptoblastic Hydroids, I may record that *Diphasia rosacea* is common on stones in Millbay Channel.

The Campanularian medusæ offer great difficulties in the way of satisfactory identification, owing to our ignorance of the limits of growth and modification of which so many of the medusæ are capable after liberation; I will therefore content myself with descriptions in several cases. Several specimens of a large, delicate, and perfectly transparent medusa were dipped up from the boat's side on October 6th, 1892, which I found, upon examination, to be the *Irene pellucida* of Will, redescribed by Claus in the Arbeiten des Zoologisches Inst. zu Wien, iv. This medusa is the *Geryonopsis pellucida* of Forbes' monograph (p. 40), but is altogether distinct from the species described by Haeckel under the name *Irene pellucida.* The umbrella was depressed and broad, 2·4 cm. in diameter. The gonads extended 8 mm. from the edge of the umbrella, *i. e.* only two thirds of the radius. There was a distinct peduncle (*Magenstiel*), conical in form, 5 mm. long. The oral lips, four in number, were produced and fimbriated. The tentacles, sixty-four in number, were very regularly disposed (4 + 4 + 8 + 16 + 32). The primary and secondary tentacles were as long as or longer than the oral lips, and the tentacles of the remaining orders diminished regularly in size and length according to their respective orders. Each tentacle consisted of a basal bulb and a terminal filament, often coiled. There was no trace, however, of true "spiral cirri." In addition there was also a variable number of tentacle rudiments, devoid of filaments, in positions which indicated the commencing formation of a sixth order of tentacles, sixty-four in number. Otolithic vesicles were present, usually one between every two adjacent tentacles, never more. Every tentacle was provided with an excretory pore, opening into the umbrellar cavity at the tip of a tubercle placed just above the velum. The species differs from the *Irene pellucida* and *Irene viridula* of Haeckel's monograph in the absence of spiral cirri. From the former it also differs in the fimbriation of the oral lips, in the absence of a conspicuous constriction between peduncle and stomach, in the regularity of the tentacles, and in the distal position of the gonads on the radial canals. From the *Geryonopsis delicatula* of Forbes it differs in the regularity of the tentacles, in the absence of a conspicuous contraction of the peduncle, and in the smaller size of the oral lips and of the velum.

In addition to *Laodice cruciata* (= *Thaumantias pilosella* of Forbes and the "Irene viridula" of Mr. Bles's *Notes on the Plankton of Plymouth,* this Journal, II, 1892, p. 342), which is common at Plymouth every summer, numbers of an *Irene*-like Phialid were taken in the tow-nets during August, 1893. The tentacles were regular, and sixteen in number. One or generally two otocysts were situated between every two adjacent tentacles. There were no cirri. The mouth had four very short lips, absolutely smooth; and there was no peduncle. The gonads formed four oval swellings almost at the distal extremities of the four radial canals.

Early in February this year I again saw a number of Leptomedusæ resembling those just described in many respects, but approaching more nearly Haeckel's *Phialidium variabile.* The size was in some cases as much as that of a threepenny piece. The tentacles, sixteen in number, were long, and arose from stout pigmented bulbs. There was one otocyst between every two adjacent tentacles, and in one instance I saw two in that position. No peduncle. Radial canals four; gonads oval, elongated, in the distal halves. The species at first suggested to me the *Epenthesis cymbaloidea* of Haeckel, but the occasional occurrence of two otocysts in an intertentacular arc, the absence of a distinct ocellus, and the sharp boundary between the basis and filament of the tentacles, eventually inclined me towards *Phialidium variabile.*

Another Leptomedusa which it may be useful to record is the *Thaumantias octona* of Forbes, which I observed on two occasions in February and March, 1894. Haeckel places this medusa in the genus *Eucope,* owing to his belief that the "two vesicles" which Forbes describes and figures in juxtaposition on the edge of the umbrella are the optical expression of an otolithic capsule. These bodies, however, are quite separate from one another, as described by Forbes; and although I am not able to throw any light on their function or fate, I may say that Haeckel's suggestion is devoid of foundation.

The interesting Lucernarian *Depastrum cyathiforme* was twice obtained last year, in March at Drake's Island, and in May at Rame Head. One of the specimens obtained at the latter place exhibited a distinct lateral bud, a phenomenon not hitherto recorded, I believe, among Lucernarians.

CTENOPHORA.—A number of specimens of the lobate Ctenophore *Bolina hydatina* were obtained on several occasions in the Sound during the latter half of May this year. Many of the specimens were of the full size mentioned by Chun in his monograph, viz. up to 4 cm. in length, and were obtained in capital condition in spite of their extreme delicacy. The species was first identified at Plymouth by Mr. Riches, who noticed specimens in the tow-nets towards the end of May, 1892. Its recurrence at exactly the same period this year renders all the more remarkable its apparent absence from Plymouth during the intermediate year, especially when the calmness and warmth of that summer are taken into consideration.

ANTHOZOA.—During May, both in 1893 and 1894, the Leptomedusæ which then abounded in the Sound, and which seemed to be in part the young stages of *Irene pellucida,* and in part *Phialidium variabile,* were infested to a large extent with parasitic Actinian larvæ, which I had little doubt (after external examination only, however) were the young stages of *Halcampa chrysanthellum.*

In my notes on the fauna for 1892 (Journal, 1892, p. 334) I recorded *Bunodes coronata* as occurring at Plymouth. This is perfectly true, but the species which I intended at the time to record was *Bunodes verrucosa* (= *gemmacea* of Gosse). *Chitonactis coronata* (the *Bunodes coronata* of Gosse) has been taken on many occasions in the deeper water outside the Breakwater, as well as once or twice in the deep water of Millbay Channel. I have no doubt that those who are familiar with the recent changes and present state of Actinian nomenclature will forgive my momentary confusion of names, which I now correct.

In my former list I omitted to mention that *Epizoanthus incrustatus* * is common at Plymouth on a patch of ground a short distance south of the Mewstone, where it covers the shells tenanted by *Anapagurus lævis.* Another species of Zoanthid, *Epizoanthus couchii,* which is common in the Sound around the Duke Rock, and to a less extent in Millbay Channel, in which localities it may be found forming linear or retiform colonies over stones and shells.

TURBELLARIA.—Mr. Gamble identified as *Fecampia erythrocephala* (Giard) a remarkable Rhabdocœle which he found infesting a large percentage of young shore-crabs (*Carcinus mænas*) in the summer of 1893. I had seen a few specimens previously in basins in which some coralline from tide-pools had been placed; they must have just emerged from the crabs in the coralline. The curious cocoons formed by *Fecampia* are also very plentiful on stones at Plymouth, both on the shore and down to a depth of 5 or 6 fathoms.

CHÆTOPODA.—I am unable to refer to Miss Buchanan's preliminary report on the Polychæta of Plymouth (Brit. Assoc., 1892), but at the risk of repetition will record here a few species which I believe are not mentioned in her list. A single mutilated specimen of *Maldane cristagalli* of Claparède was dredged on a patch of ground, consisting of hard rock and intervals of sand, a short distance south of the Breakwater Fort on December 14th, 1892. It was associated with specimens of *Glycera capitata* and *Eunice Harassii.* The former, however, lives at Plymouth wherever there is abundance of clean coarse shell sand, and *Eunice Harassii* is not uncommon in Millbay Channel and around the Duke Rock, where it lives in holes of stones.

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* The nomenclature of Haddon's *Revision of British Actiniæ* (Trans. Roy. Dublin Soc., vol. iv, 1891) is here followed.

It is also sometimes taken on the shore. The much larger Eunicid, *Marphysa sanguinea,* is common both in Rum Bay and at Drake's Island. It inhabits deep crevices of the rocks, and can only be obtained by breaking the latter to pieces by means of a crowbar.

On January 26th, 1893, I noticed among a number of *Phyllodoce maculata,* which emerged from material dredged off the west shore of Drake's Island, two specimens of a charming white *Phyllodoce* with reddish eyes, which I was not able to identify. *Each segment except the most anterior ones was provided with a girdle of cilia.* The parapodial lamellæ were fan-shaped, and each was marked with a brown, or rather a fawn-coloured spot. The inferior edge of each lamella was also provided with large vibratile cilia. The back of the worm was faintly pigmented with fawn-colour. The small but handsomely marked Syllid, *Proceræa picta* of Ehlers, is fairly common among the stones dredged in Millbay Channel. A species of *Myrianida** is constantly recurring at Plymouth, one or two specimens at a time. I believe it is identical with the *Myrianida maculata* of Claparède, though I cannot at present say whether it is different from the *Myrianida pinnigera* of Montagu, whose original description I have not seen. It is easily recognised by its colour, which is white, with deep orange-red blotches on the back of every third or fourth segment. It is fairly frequent among the roots of *Laminaria.* On one occasion (May 29th, 1893) I found a specimen under a stone at the Breakwater, which was provided with a chain of buds, some of which had detached themselves before my return to the laboratory. *Amblyosyllis* (*Gattiola*) *spectabilis,* I find, is a spongicolous form, and can often be obtained in quantity by tearing open the larger sponges, of *Desmacidon*-like texture, dredged in Millbay Channel. A large eyeless *Polydora* (? *flava,* Claparède) is common in Rum Bay, and at Rat Island in St. German's River, where it constructs mud burrows between the layers of shaly rock. In February I have found many of these burrows also containing a long segmented gelatinous egg-string, almost as long as the worm itself (*i. e.* about two inches), lying flat and straight in the burrows. The worm itself possesses a bifid præoral lobe, and the branchiæ commence on the eighth segment (*i. e.* the third after the apodous segment). The dorsal blood-vessel is conspicuous, the blood being crimson. At Rat Island I have also taken specimens of *Scoloplos armiger,* living, like the *Polydora,* in the mud between layers of shale, and also in the dirty sand around. In November, 1892, a single specimen of the remarkable *Ammotrypane aulogastra* of Rathke (*non* Johnston) was dredged off the Duke Rock.

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* Good figures of this species are given by Malaquin (*Mem. Soc. des Science et des Arts,* Lille, 1893, p. 287, pl. i), who identifies the *Myrianida maculata* of Claparède with the *M. fasciata* of Milne-Edwards.

Two specimens of the pelagic post-larval stage of *Arenicola* (described in this Journal, III, 1893, p. 48, by Dr. Benham) were again obtained this year in February, but about a fortnight earlier than in 1893.

Gephyrea.—*Phoronis hippocrepia* has been frequently dredged, especially in Millbay Channel, and I have also taken it on the shore at Cremyll.

Mollusca.—Several specimens of *Lima Loscombii* have been taken alive in about 20 fathoms off Stoke Point and south of the Mewstone. Large specimens of *Arca tetragona* can be obtained in Rum Bay by breaking the rocks there to pieces with a crowbar. They live in deep holes and crevices of the rocks, to which they are permanently attached by their stout operculum-like byssus. In the majority of cases the shells are remarkably abraded and polished by the efforts of the molluscs to enlarge the crevices in which they are fixed, so as to make room for their own increasing size. Not only is their layer of bristles entirely worn away in many cases by this friction of the valves against the surrounding rock, but the rock itself is rubbed away and polished by the incessant friction. In many cases I found the rock to be an almost perfect mould around the mollusc, while the aperture to the crevice by which the larval or young *Arca* had originally entered was not large enough to admit a specimen of even half the bulk to which the mollusc had attained!

A remarkably elongated specimen of *Loligo media* was trawled on April 14th, 1893, eight miles south of the breakwater. I took the following notes of its dimensions:

Maximum length of mantle . . .	136 mm.
,, breadth of fin . . .	27 ,,
Anterior extremity of fin to apex of body .	98 ,,
Posterior ,, ,, ,, ,, .	43 ,,

The extraordinary abundance of the Tectibranch *Philine aperta* during 1893 has been already mentioned. Hundreds of specimens could easily be obtained at any time in the eastern portion of the Sound, and the species with its gelatinous egg-masses was so abundant in July as to choke the meshes of the shrimp-trawl when worked in Jennycliff Bay. *Oscanius membranaceus* also, though not so abundant as *Philine*, was unusually plentiful, especially in Millbay Channel and the Hamoaze.

In February of this year I found a single specimen of an apparently undescribed * type of Tectibranchiate mollusc which unites in

* This is the *Colpodaspis pusilla* of Michael Sars, a very rare and interesting form, of which only two specimens have previously been obtained.

a remarkable manner the most salient characters of the Notaspidea and Cephalaspidea. I have prepared figures of this little animal, a description of which will be published immediately.

Several rare Nudibranchs have been taken, chief of which are the Æolid *Berghia cœrulescens* and *Hero formosa.* Both forms inhabit the deeper waters outside the Breakwater, and the latter is by no means uncommon. Additional captures have also been often taken of *Æolidiella glauca* and *Platydoris planata,* and, less frequently, of *Amphorina cœrulea, Antiopa hyalina, Embletonia pulchra, Hermæa bifida,* and *Thecacera pennigera.* The specific habits of most of these forms are still unknown, but in the case of two Dorids, *Rostanga coccinea* and *Lamellidoris oblonga,* the following observations upon their habits may be useful. Just as *Jorunna Johnstoni** lives among small *Halichondriæ,* upon which it feeds, and which it strikingly mimics in general and even detailed appearance, so I have found that *Rostanga coccinea,* which is of a bright scarlet colour, lives—in both senses—upon red encrusting sponges. This species, which formerly seemed to be rare at Plymouth, I have been able to obtain easily by dredging or collecting in those places where its food-sponges are abundant. On the other hand, *Lamellidoris oblonga* lives not upon sponges, but upon Polyzoa of the genus *Cellaria,* especially the stouter species, the twigs of which it clasps firmly with its foot. This Dorid is not well described by Alder and Hancock, no doubt from their lack of a sufficient number of specimens from which to educe the characteristic features. The back normally shows a variable number of irregular, ring-like, dark spots (of which there are usually eight or nine more conspicuous than the rest), and round the entire periphery of the back there is a pigmented border, which has no sharply defined edges, but is a marked feature when a number of specimens are examined and compared. The edges of the rhinophoral fossæ are raised into a slight rim or sheath provided with three tubercles. The chief differences between individuals for the most part concern simply the relative intensity of the brown pigmentation: the annular spots and border were indistinguishable in only three out of forty specimens. I first noticed this species on December 19th, 1892, when scores of specimens were taken from *Cellaria* trawled seven miles south of the Breakwater. With them were associated a few specimens of *Lamellidoris pusilla* and *Lamellidoris proxima.*

Another small Dorid, whose back is strikingly marked by conspicuous purple tubercles upon a field of yellow, seems to be new to science, and will be described elsewhere.

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* Garstang, *Notes on the Structure and Habits of* Jorunna Johnstoni, Conchologist, vol. ii, 1892.

In November, 1892, among coralline from tide-pools, I repeatedly found specimens of a minute white Dorid, whose back exhibited a regularly arranged series of very spiny tubercles. I was completely at a loss as to its identification, until towards the end of the month several slightly larger specimens were taken, which showed traces of pigmentation,—brownish patches here and there, and a brown ring on each rhinophore. During the next month or two I followed out the growth of these little Nudibranchs by obtaining fresh specimens from the tide-pools from time to time, until I had a complete series between the minute and absolutely white form and the fully developed and highly pigmented *Ægirus punctilucens.* From these observations I am strongly inclined to regard the *Ægirus hispidus* of Hesse as merely one of the younger stages of *Ægirus punctilucens.* They also enable me to identify, as a still earlier stage of the same species, a remarkable post-larval form which had occurred in the autumn tow-nettings, as observed both by Mr. Bles at Plymouth and Mr. Vallentin at Falmouth. It was simply one of these minute white *Ægirus* with the addition of a pair of large velar lobes, by means of which it swam freely in the water.

Two other Gastropod larvæ that I have noticed in the tow-nettings are worthy of record. One is the *Echinospira diaphana,* figured in Bronn's Thier-Reichs, and the other the *Cirropteron semilunare* of Michael Sars (Besk. og Jagttag., &c., Bergen, 1835). In each of these forms the velum is produced into ciliated lobes, three on each side in *Echinospira,* and two in *Cirropteron.* The former occurs in the summer tow-nettings every year; the latter I have only seen once, towards the latter end of August, 1893.

Crustacea.—To my former record of *Apseudes talpa* I may add here the occurrence of *Apseudes Latreillii* at Plymouth. I found numerous specimens in the mud around the roots of corallines from Drake's Island in July, 1893, and on other occasions.

In addition to the Schizopoda mentioned in my previous Notes, I have taken the following also at Plymouth:—*Siriella frontalis* (M. Edw.), Drake's Island, among weeds, June 2nd, 1893, one specimen. *Siriella jaltensis,* which occurred in the tow-nets at night in September, 1892, abundant on the shore at Drake's Island among weeds, June 2nd, 1893. *Heteromysis formosa* (S. I. Smith), a few at a time only, Millbay Channel, New Grounds, Cawsand Bay, Yealm, and off Stoke Point. *Leptomysis mediterranea,* common in Cawsand Bay, June 5th, 1893. *Leptomysis gracilis,* October, 1893. *Erythrops elegans,* October, 1892 and 1893. *Mysidopsis gibbosa,* Cawsand Bay, several occasions. *Hemimysis Lamornæ,* Cawsand Bay, July 5th, 1893. *Macromysis inermis* and *M. neglecta,* among weeds everywhere. *Schistomysis arenosa,* Cawsand Bay, Whitsand Bay.

The form "allied to *S. arenosa*," referred to in my previous Notes, is this species, as Canon Norman, who kindly examined some specimens, has assured me.

Nika edulis has been trawled in the Sound occasionally, but is rare.

Pirimela denticulata is not uncommon in the patches of clean coarse shelly gravel to the south of Drake's Island. Its highly speckled appearance renders it very inconspicuous on this ground, into which, however, it promptly burrows so as to be completely hidden from view.

Stenorhynchus egyptius (M. Edw.) is not uncommon on weedy ground, and is at once distinguishable from the other spider-crabs by its stripes of reddish-brown pigment. The habit of decking the body and limbs with bits of seaweed is as marked in this species as in any of the others, and as it generally lives among reddish weeds its own coloration contributes greatly to its disguise.

ECHINODERMA.—During August, 1893, the tow-nets frequently contained one or two specimens of the interesting type of *Bipinnaria* larva described by me in the Quart. Journ. Micr. Sci., January, 1894.

TUNICATA.—During August and September, 1893, a considerable number of specimens of a small *Doliolum* were found in the tow-nettings. They agree with Herdman's *Doliolum tritonis* in all respects except that the stigmata begin dorsally close behind the second muscle band,—a point of no great importance. When alive these little creatures are perfectly transparent, and dart about with great activity in the water.

Earlier in the year—from the middle of June to the end of the first week in July—the Sound was visited by large shoals of the Salp *Thalia democratica-mucronata*. Many of the specimens first taken were of the sterile or nurse generation, and were provided with young chains; the later specimens, on the other hand, were chiefly sexual forms derived from the breaking up of the chains, and a large number of these contained embryos—one only to each adult—in different stages of development.

II. NOTES ON THE BREEDING SEASONS OF MARINE ANIMALS AT PLYMOUTH.

These notes are founded almost entirely on my own observations, and are necessarily incomplete, though, I believe, not inaccurate. My original intention was to continue such observations for at least another year before publication, in order to be able to present a fairly complete record; but my departure from Plymouth has interfered with this plan, and, at the request of several friends, I publish my notes as they are. They will serve, I hope, as at least an indication of the breeding periods of many forms at Plymouth. A more extensive list, including the records given in various monographs and original memoirs, for the whole of the British Isles, is at present under preparation, and will be presented for publication at no distant date.

PROTOZOA.

Noctiluca miliaris.—(Swarm-spores) March (S. F. Harmer).

PORIFERA.

Principally July, August, September.

HYDROZOA.

In those Hydroidea which possess sessile gonophores or sporosacs the breeding season may be regarded as practically coincident with the period of gonophore-formation, although actually a little later; but in the case of those Hydroids which attain maturity in the form of free medusæ, the time that may elapse between the separation of the medusæ and the deposition of ova is in the majority of cases still unknown, and is certainly not a constant quantity. The periods given here will therefore be the periods of gonophore- or sporosac-formation. The breeding seasons of free medusæ may be regarded as the periods when they attain their full growth and greatest abundance—information upon which points may be gathered from the third section, dealing with the floating fauna.

Tubularia indivisa.—February, March, April.
Tubularia larynx.—April.
Tubularia bellis.—April.
Tubularia humilis.—March.
Myriothela phrygia.—May to August (Bourne).
Clava multicornis.—March, April.
Clava leptostyla.—March.
Clava cornea.—February (Bourne), May.
Tubiclava cornucopiæ.—May, June.
Hydractinia echinata.—August.
Perigonimus repens.—August.
Podocoryne carnea.—August (and earlier).
Coryne pusilla.—May; July (Bourne).
Coryne vaginata.—May to August (Bourne).
Syncoryne eximia.—May (Bourne).
Eudendrium ramosum.—February, March.
Eudendrium capillare.—May, September.
Garveia nutans.—April.
Obelia geniculata.—March, September.

Gonothyræa Loveni.—April, October, November (sparsely).
Sertularia argentea.—February.
Sertularia pumila.—March, April, May, June, July.
Diphasia pinnata.—April.
Diphasia rosacea.—April.
Sertularella Gayi.—February, August, September, October.
Hydrallmania falcata.—January.
Halecium Beanii or *halecinum.*—January to July.
Plumularia setacea.—February to June.
Plumularia pinnata.—April.
Antennularia antennina.—May, June, July.
Antennularia ramosa.—May.
Aglaophenia pluma.—August.
Aglaophenia myriophyllum.—August.
Aglaophenia tubulifera.—October.

SIPHONOPHORA.
Muggiæa atlantica.—August, September (J. T. Cunningham; E. J. Bles).

SCYPHOZOA.
Aurelia aurita.—(Strobilising) February, (breeding) June, July.

ANTHOZOA.
Alcyonium digitatum.—November, December, January.
Actinia equina.—January onwards (to August ?).
Bunodes verrucosa (*gemmacea*).—April, September.
Urticina felina (*Tealia crassicornis*).—May.
Chitonactis coronata.—January to April.
Cereus pedunculatus (*Sagartia bellis*).—December, January, February.

TURBELLARIA.
Fecampia erythrocephala.—August, September.
Leptoplana tremellaris.—August (F. W. Gamble).
Eurylepta cornuta.—August (Gamble).
Stylostomum variabile.—August (Gamble).
Cycloporus papillosus.—August (Gamble).

NEMERTINA (cf. Riches, Journ. M. B. A., III, 1893, p. 5).
Cephalothrix bioculata.—April, June.
Cephalothrix linearis.—March.
Amphiporus lactifloreus.—March.
Amphiporus pulcher.—September.
Amphiporus dissimulans.—March, September, October.
Tetrastemma dorsale.—September, October, November.

Tetrastemma candidum.—September, October, November.
Tetrastemma vermiculatum.—September, October, November.
Nemertes Neesii.—March to October.
Lineus obscurus (= *gesserensis*).—January, February.

ARCHIANNELIDA.
Dinophilus tæniatus.—April (Harmer).
Histriobdella Homari.—September (E. J. Allen).

CHÆTOPODA.
Ophryotrocha puerilis.—August.
Nereis fucata.—May.
Phyllodoce maculata.—January, February.
Hesione (= *Psamathe*), sp.—August.
Scoloplos armiger (?).—February.
Polydora (*flava* ?).—February.
Sabellaria spinulosa.—May.
Serpulidæ.—June.
Terebellidæ.—May.
Polycirrus aurantiacus.—July.
Cirratulus cirratus.—February (and earlier).

HIRUDINEA.
Pontobdella, sp.—August (advanced embryos only).

POLYZOA.
Crisia ramosa.—July.
Flustrella hispida.—March.
Smittia, sp.—March (Harmer).

MOLLUSCA.

Amphineura.

Chiton, sp.—March.

Gastropoda.

Littorina littorea.—February.
Littorina littoralis.—February.
Littorina rudis.—June.
Capulus hungaricus.—January, February, March.
Buccinum undatum.—January, February, March, April.
Purpura lapillus.—January, February, March, April, November.
Murex erinaceus.—May (and earlier).
Nassa reticulata.—February, March, April, July, September.
Nassa incrassata.—April, June, August, September.
Lamellaria perspicua.—January to May.

Aplysia punctata.—June to October.
Philine aperta.—May, June, July.
Elysia viridis.—October (and earlier ?).
Hermæa dendritica.—June.
Æolis papillosa.—March, April, May, June.
Æolidiella Alderi.—August.
Favorinus albus.—November.
Facelina coronata.—April, May.
Galvina Farrani.—May, October.
Galvina exigua.—March.
Galvina cingulata.—July.
Tergipes despectus.—March.
Doto fragilis.—January.
Doto coronata.—April.
Candiella (*Tritonia*) *plebeia.*—November.
Hero formosa.—April.
Doris tuberculata.—January to June.
Acanthodoris pilosa.—January, February.
Lamellidoris bilamellata.—November (?).
Lamellidoris oblonga.—April.
Lamellidoris pusilla.—February.
Goniodoris nodosa.—December, January to May, September.
Goniodoris castanea.—February, May, July, September.
Polycera quadrilineata.—July, August.

Lamellibranchia.

Arca tetragona.—July.
Teredo navalis.—May.

Cephalopoda.

Eledone cirrosa.—April, May.
Sepiola atlantica.—July, August.
Loligo media.—April, May, June, October (late embryos).
Loligo Forbesii.—April to September.

CRUSTACEA.

Cladocera.

Podon (*intermedius*, Lilljeborg ?).—March, April, June (?).
Evadne Nordmanni.—March (scarce), July, August, September. Winter ova in September and October (E. J. Bles).

Copepoda.

Some forms or other may be found breeding at almost any time of the year.

Cirrhipedia.

Chthamalus stellatus.—January, February, March, August, September.

Sacculina carcini.—May, June, July, August, September.

Leptostraca.

Nebalia bipes.—April, May, June, July (late embryos).

Edriophthalmata.

The great majority breed between April and August.

Cumacea.

Pseudocuma cercaria.—May, June.

Schizopoda.

Siriella jaltensis.—June.
Gastrosaccus sanctus.—August.
Gastrosaccus Normani.—September.
Heteromysis formosa.—October, November.
Erythrops elegans.—October (late embryos only).
Mysidopsis gibbosa.—July.
Leptomysis mediterraneæ.—June.
Macromysis flexuosa.—April, May, June, July.
Macromysis inermis.—June.
Schistomysis arenosa.—June.
Schistomysis spiritus.—June, July, August (late stages only).

Decapoda.

Homarus vulgaris.—August, September. Larvæ hatched in May and June.
Palinurus vulgaris.—Larvæ hatched in July (Cunningham).
Palæmon serratus.—November, December, January to June.
Palæmon squilla.—July (and earlier).
Palæmonetes vulgaris.—May, June, July, August (late stages only).
Pandalus annulicornis.—November, December, January, February.
Pandalus brevirostris.—April.
Hippolyte Cranchii.—April, May.
Virbius varians.—May, June, July.
Nika edulis.—May.
Crangon vulgaris.—December, January to August.
Crangon fasciatus.—May.

Crangon sculptus.—June.
Crangon trispinosus.—July.
Diogenes varians.—July.
Eupagurus Bernhardus.—April.
Eupagurus Prideauxii.—March, April, May, June, July.
Anapagurus lævis.—April, May.
Galathea squamifera.—April.
Galathea dispersa.—March.
Galathea intermedia.—March.
Porcellana longicornis.—March, April, May, June, July.
Porcellana platycheles.—April, May, June, July.
Eurynome aspera.—January, February, March, April.
Stenorhynchus phalangium.—May.
Stenorhynchus tenuirostris.—May.
Hyas coarctatus.—August.
Carcinus mænas.—December, January to August.
Portunus depurator.—March to August.
Portunus holsatus.—March.
Portunus arcuatus.—March, April, May.
Portunus pusillus.—April.
Portunus marmoreus.—May.
Pilumnus hirtellus.—April, May, June.
Xantho floridus.—May, June.
Xantho rivulosus.—May, June.
Cancer pagurus.—February to ?.

PANTOPODA.

Nymphon gracilis.—May.
Ammothea, sp.—August.

ECHINODERMA.

Asterias rubens.—May.
Asterina gibbosa.—May, June.
Ophiothrix (*? pentaphyllum*).—February.
Amphiura squamata.—May, June, July.
Echinus miliaris.—May.
Echinus acutus.—July.
Antedon rosacea.—Pentacrinoid larvæ in September and October.

TUNICATA.

Oikopleura dioica.—March, April.
Thalia democratica-mucronata.—July.
Botrylloides rubrum.—August, September, October.
Botryllus violaceus.—June, July, August.
Styelopsis grossularia.—May, June, July, August, September.

Ciona intestinalis.—September (and earlier?).
Clavelina lepadiformis.—June.
Archidistoma aggregatum.—June.
Morchellium argus.—September (and earlier?).
Amaræcium Nordmanni.—June.

PISCES.

Elasmobranchii.

Scyllium catulus.—November, December, January.
Scyllium canicula.—December, January, February.
Acanthias vulgaris.—January, February, March.

Teleostei.

Chiefly between January and June.

III. MATERIALS FOR A CALENDAR OF THE FLOATING FAUNA.

The floating fauna of the sea in the immediate neighbourhood of land is so largely composed of larval or other forms derived from the bottom fauna, and possessing in the majority of cases only a transitory pelagic existence, that, from the very nature of the case, the floating fauna assumes a highly periodical character, whose phases are directly dependent on the seasons of breeding, hatching, and metamorphosis of the animals living on the adjacent or underlying tracts of submarine land. This fact alone invests the recording of such simple phenomena as the breeding seasons of marine animals, or their rates of growth and metamorphosis, with a high degree of interest and value; and in the days to come, when this fact has been sufficiently and practically appreciated, we shall make much more rapid progress in our knowledge of the bionomics of the sea. The dependence of the floating and the bottom faunas of our coasts upon each other is so intimate that it is impossible to separate the efficient study of the one from that of the other. A bottom-haunting species no sooner attains its breeding or its hatching period than the floating fauna immediately receives a new addition to its numbers. For a longer or shorter period the larvæ in question lead a pelagic life, and then, sooner or later, sink once more to the bottom to undergo their final transformations. Seeing that every species has its own particular breeding season, which does not necessarily coincide with that of any other species, and that the duration of the pelagic stage is equally variable in different cases, it follows that there must be a perpetual change going on in the constitution of the floating fauna in any one locality, an incessant rising to the surface of new forms just commencing their pelagic phase, and an incessant sinking to the bottom of surface larvæ whose floating period has come to an end. Were our work completed, our calendar of the floating fauna would largely coincide with, or bear a definite relation to, our calendar of the breeding seasons of bottom-living animals; but the insufficiency of present records, combined with their obvious want of mutual correspondence, shows what a large amount of observation and work remains to be done before the desired pitch of correspondence is attained.

The periodic character of the floating fauna is also manifested in other ways, and especially in certain seasonal changes which the gradual rise or fall of temperature during the year superinduces. These changes are due to actual immigrations of forms whose homes for the most part are in other regions, but which arrive at particular points upon our coasts when the temperature and other physical conditions admit of, and conduce to, their migration. The periodical changes which were first dealt with here were those of larval or metamorphic forms (*e. g.* most medusæ), whose derivation from the bottom fauna, and, in most cases, whose eventual return to it give rise to an incessant *vertical* interchange of material; but the forms which are especially concerned in these seasonal changes are for the most part creatures whose entire existence is pelagic (*e. g.* Siphonophores, *Trachomedusæ*, Copepods, *Sagitta*, *Salpa*), and which exhibit a merely *horizontal* translation from place to place according to the stress of physical conditions.

The situation of Plymouth at the head of a landlocked bay and at the western end of the English Channel renders the study of its floating fauna both difficult and interesting. This fauna is in fact not one fauna, but three faunas,—that of the harbour itself, which may be called the indigenous element; that of the adjacent coasts and of mid-Channel, which may be termed the tidal or Channel element; and that of the Atlantic, or the oceanic element. It is only by taking special precautions that one can isolate the first of these constituents from the other two, viz. by tow-netting within the Breakwater at low tide, when the wind has been light or northerly. At high water the Sound is naturally invaded by foreign forms carried inwards by the flood tide, and this may include eddies from the Channel tide properly so called; while protracted southerly or westerly winds inevitably produce an incursion of pelagic forms from the Channel or the ocean. A special study of the floating fauna would therefore take all these points into practical consideration, and I mention them here in order to warn those who may use these brief notes of the different factors of which the fauna at Plymouth consists, and of the impossibility, after the irregular experience of a few years only, of producing a calendar which shall in all points discriminate properly between the essential and the accidental phenomena observed.

Notwithstanding this consideration, however, and in spite of the incompleteness of my records, of which no one is more conscious than myself, I believe that I am in a position to offer a least the groundwork for the construction of such a calendar,* the completion of which would be an incalculable boon to the working naturalist, and lead to results of which one can dimly foresee the nature and importance.

January.—The tow-nettings in January are a trifle richer than those taken in December, but beyond that possess few positively distinctive features.

The alga *Halosphæra viridis* is usually present.

There is a marked scarcity of Cœlenterate life. The jars often seem to contain nothing but Copepods† and a few *Sagitta,* which, however, are usually large at this time of the year.

The Invertebrate larval forms present are Cirrhipede *Nauplii,* Polychæte trochospheres and later larvæ, with a few veligers and *Zoææ.*

Teleostean ova and larvæ make their appearance and increase in numbers towards the end of the month. Herring larvæ (*Clupea harengus*) are now taken.

The fauna distinctly ameliorates towards the end of the month.

February.—The improvement, both quantitative and qualitative, of the floating fauna, which was noticeable towards the end of January, becomes marked this month.

Teleostean ova and larvæ are plentiful.

The sea swarms with Copepod and Cirrhipede *Nauplii,* with Polychæte larvæ (Polynoidæ, Phyllodocidæ), with Prosobranch, and especially Opisthobranch veligers, and with Decapod larvæ, both *Mysis* and *Zoæa* stages.

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* Since my paper was written I have found that my idea of a calendar of the floating fauna is not new, and that a very full and valuable summary of the periodic changes in the pelagic fauna of St. Andrews was published by Prof. McIntosh in 1889 (Seventh Report, Scottish Fishery Board), part iii, pp. 259—301). The resemblances and differences between our records are of considerable interest.

† It is easily observable that various species of Copepods are also periodic in their occurrence, but I do not refer to them in these notes, as I have not yet familiarised myself with the different forms and names. Reference should be made on this point to Mr. G. C. Bourne's *Report on the Copepoda of Plymouth,* this Journal, vol. I, 1889, pp. 144—152. It would appear from Mr. Bourne's report that *Clausia elongata* is characteristic of the three last and three first months of the year ; *Oithona spinifrons, Euterpe gracilis,* and *Corycæus anglicus* of the spring (though the two latter species have been recorded for September by Mr. Bles); *Paracelsus parvus* of the summer; *Temora longicornis* of the early summer and autumn; *Anomalocera Patersonii* of the autumn. *Cetochilus septentrionalis* (= *Calanus finmarchicus*) and *Dias longiremis* were obtained throughout the year; but the former most abundantly in the autumn, the latter in the spring.

Cœlenterates make their appearance. The ephyræ of *Aurelia* lead the way, and become increasingly abundant. *Rathkea octopunctata* represents the Anthomedusæ; and a medusa that appears to be the *Phialidium variabile* of Haeckel ushers in the Leptomedusæ. Minute *Obelia* medusæ become noticeable as the month progresses. Occasionally the Channel tide introduces the ova and larvæ of Ctenophores and errant specimens of the Siphonophore *Muggiæa atlantica.*

The Polyzoan larvæ *Cyphonautes* and the larvæ of Lamellibranchs are common; and the pelagic post-larval stage of *Arenicola,* in its gelatinous tube, may from time to time recur.

Echinoderm larvæ, especially *Auricularia,* are usually abundant during a portion of the month.

The Appendicularian *Oikopleura dioica* is often plentiful.

March.—*Halosphæra* is plentiful this month, and *Rhizoselenia* and *Chætoceros* often become extremely abundant.

At the end of the month the gelatinous alga *Tetraspora* of Pouchet makes its appearance, first in the Channel and soon afterwards in the harbour.

Shoals of ephyræ of *Aurelia* may be taken in the first fortnight, showing a distinct increase in size since their first appearance; but towards the end of the month, during their metamorphosis into the medusa form, they begin to disappear and are difficult to discover.

Rathkea octopunctata is plentiful. The Anthomedusæ *Sarsia prolifera* (and *tubulosa?*) and *Podocoryne* (*Dysmorphosa*) *carnea* make their appearance; and the earlier phases of the Leptomedusæ *Clytia Johnstoni* and *Irene pellucida* (Claus, *non* Haeckel) are to be obtained, together with numbers of small *Obelia* and a few *Thaumantias.*

The Cereanthid larva *Arachnactis* appears, and is plentiful towards the end of the month.

Minute Planarians are sometimes noticeable.

The later stages of *Phyllodoce* larvæ are plentiful; the larvæ of *Polydora* also occur.

Crustacean larvæ of all kinds abound, and the *Zoœæ* of *Porcellana* begin to appear.

The Cladocera *Podon* and, more scantily, *Evadne* arrive. Echinoderm larvæ (*Auricularia, Bipinnaria, Pluteus*) occur at times.

A striking feature of March tow-nettings is the profusion of the Appendicularian *Oikopleura dioica,* which is now breeding; its gelatinous houses (a mysterious scum to the unwary) are often a great nuisance, but a greater is to follow.

April.—*Tetraspora* abounds, discolouring the sea and choking the meshes of the nets in two or three minutes. Towards the end of the month these floating and troublesome algæ begin to be converted into so many gelatinous balls of motile spores.

The Diatoms *Rhizoselenia* and *Coscinodiscus* also abound, but *Halosphæra* disappears until the autumn.

Among Anthomedusæ, *Rathkea* disappears and *Bougainvillea* takes its place. *Amphicodon amphipleurus* may also occur. Among Leptomedusæ, small medusæ of *Obelia* and *Clytia* are numerous.

The later stages of *Arachnactis* are represented.

Larvæ of the Nemertine *Cephalothrix* may be found.

It is impossible to speak with much confidence, but there appears to be a rapid reduction during this month of the numbers of *Nauplii* and Polychæte larvæ.

Megalops larvæ become increasingly numerous. Large Portunid *Zoææ* make their appearance towards the end of the month.

Plutei are almost the only Echinoderm larvæ, and they do not seem to be plentiful.

May.—The formation of spores in *Tetraspora* proceeds apace, and leads to a rapid reduction in the numbers of the alga already noticeable early in May. Towards the end of the month the gelatinous alga has entirely disappeared.

The sea swarms with Craspedote medusæ, especially with those of the Campanularians, *e. g. Obelia lucifera* of fair size, *Phialidium variabile* (?), *Thaumantias,* and half-grown *Irene pellucida.* The most abundant Anthomedusa is *Corymorpha nutans,* but *Amphinema Titania* and *Tiara octona* also may occur.

Full-grown Ctenophores usually become numerous in the latter half of this month; *Hormiphora plumosa* always, and the magnificent lobate form *Bolina hydatina* in particular years.

Towards the end of the month *Aurelia aurita* begins to reappear in the form of young medusæ.

The parasitic larvæ of the Actinian *Halcampa* are plentiful on Campanularian medusæ.

The Polychæte larvæ and *Nauplii,* so abundant in February and March, are now scarce.

The *Zoææ* of *Porcellana* and of Portunidæ are particularly numerous.

Every year at this time the harbour is invaded by shoals of young brill (*Rhombus lævis*) in their pelagic stage.

June.—This is the month, *par excellence,* for *Aurelia aurita* and Ctenophores. Leptomedusæ also abound; large *Obeliæ* are now plentiful, and a new form, *Laodice cruciata* (*Thaumantias pilosella* of Forbes), makes its appearance.

The first specimens of pelagic Terebellid larvæ in gelatinous tubes may perhaps be taken.

The Gastropod larva *Echinospira diaphana* always occurs.

The Cladoceran *Podon* is generally abundant, but *Evadne* is generally still in mid-Channel. *Sacculina Nauplii* are plentiful.

Minute *Oikopleuræ* of the same year's brood are frequently abundant. After an exceptionally warm, calm spring the harbour may be invaded by hordes of Salps (*Thalia democratica-mucronata*).

July.—A transition is gradually effected during July between the distinctively summer and autumn faunas.

Rhizoselenia and Dinoflagellates (*Ceratium, Peridinium*) are common.

The Anthomedusæ are represented by numbers of *Podocoryne carnea* with some *Sarsia eximia*; the Leptomedusæ by numbers of *Laodice cruciata, Obelia,* and (in the Channel) of *Saphenia mirabilis.*

The Siphonophore *Muggiæa atlantica,* which occurs during the earlier part of the year only in scanty numbers, becomes plentiful towards the end of this month.

The first specimens of *Chætopterus* larvæ may be taken.

Balanid *Nauplii* become again numerous, and *Evadne* arrives in large numbers.

Echinoid *Plutei* are to be obtained.

August.—In variety and intrinsic interest of the forms to be captured, this and the next month are perhaps the richest in the year,—a feature which accords well with the fact that during this month the sea temperature attains its maximum for the year.

The more oceanic element includes numbers of Radiolaria, *Muggiæa,* young *Geryonia appendiculata*, *Evadne* (and perhaps *Podon*), and *Doliolum Tritonis,*—all of which, after a warm summer, may occur in plenty and even profusion.

Numbers of interesting larval forms are also taken, of which the chief perhaps are Müller's larva (in shoals towards the end of the month), *Pilidium* (abundantly), Annelid larvæ (*Polygordius* occasionally, *Polydora, Pectinaria, Nerine, Magelona, Chætopterus*), Gastropod larvæ (*Rissoa, Ægirus, Cirropteron semilunare*), *Actinotrocha,* Cirrhipede larvæ (*Sacculina*), Echinoderm larvæ (*Plutei,* large *Bipinnariæ*), *Tornaria,* and the larva of *Amphioxus.*

Conspicuous among Anthomedusæ are *Amphinema Titania* and *Podocoryne* (*Dysmorphosa*); and among Leptomedusæ, *Saphenia mirabilis, Laodice cruciata,* and small *Obeliæ.*

Dinoflagellates and diatoms (*Rhizoselenia*) are plentiful.

September.—The floating fauna during September differs very slightly from that of the preceding month.

The disappearance of the medusæ *Laodice cruciata* and *Saphenia mirabilis* is effected, and *Willia stellata* appears.

Almost all the other forms plentiful in August retain their abundance for the greater part of September, the possible exceptions being *Radiolaria, Bipinnaria,* and *Tornaria.*

On the other hand Terebellid larvæ are increasingly numerous; the larvæ of *Muggiæa,* of the Nemertine *Cephalothrix,* and of the Gephyrean *Thalassema* may be found; and Müller's larvæ, *Pilidium,* the larvæ of *Magelona, Chætopterus, Rissoa,* and *Ægirus* are generally in the earlier part of the month especially plentiful.

Apparently characteristic of this period are the clouds of pelagic Rotifers which may occasionally be taken.

The diatom *Chætoceros* is especially abundant.

October.—With the end of September an impoverishment of the fauna sets in, owing chiefly to the disappearance of the more oceanic element.

Chætoceros is the most plentiful diatom. The alga *Halosphæra* reappears. Dinoflagellates are abundant, and a few Radiolaria may still occur. The following medusæ may be present:—*Cytæandra areolata, Eutima insignis,* and large *Irene pellucida.*

Nemertine larvæ, including those of *Cephalothrix,* are numerous. Polychæte larvæ of the genera *Polynoë, Chætopterus, Polydora,* and *Terebella* are still present.

Larval Lamellibranchs and *Cyphonautes* are numerous, as indeed they seem to be during the greater part of the year.

Decapod larvæ are scarce, especially those of the Brachyura. *Sagitta* is generally present, and a few *Plutei* may be taken.

November.—The impoverishment continues. There is a great scarcity of medusæ, veligers, and Zoææ. The larvæ least rare are those of Polychætes, Cirrhipedes, *Macrura,* and *Cyphonautes. Cephalothrix* larvæ and Ophiurid *Plutei* may occur.

The diatom *Coscinodiscus* is present in profusion.

December.—Medusæ are still rare or even entirely absent. Annelid trochospheres and Opisthobranch veligers show signs of increasing numbers. *Cyphonautes* is present.

Fishery Publications of the United States.

By

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In recent years the Bulletin of the United States Fish Commission has outgrown its older brother, the Report of the Commissioner, and in some respects supplanted it. The last volume of the Report, part xvii, bears the date of publication 1893, but it was only received by us in the present month of June, 1894, and it refers to operations carried out in the two years 1889–91,—in other words, from three to five years ago. The volume consists of three general reports and six appendices. The former are the Report of the Commissioner, that of Mr. Richard Rathbun on the Inquiry respecting Food-fishes and the Fishing-grounds, and that of Mr. Hugh M. Smith on the Inquiry regarding the Methods and Statistics of the Fisheries. The Appendices comprise three special reports, a Review of Sparoid Fishes, by David Starr Jordan and Bert Fesler, an article on Fish Entozoa, and a translation of Haeckel's well-known pamphlet, Plankton-Studien.

The first thing of interest which we note in the Report of the Commissioner is a statement of the amount of the appropriation of public revenue to the work of the Commission. In the year 1889–90 the total amount was $278,900, in the following year $298,900, in English money about £55,780 and £59,780 respectively. In the second of the two years mentioned the division of this money among the various departments of the work was as follows:

Commissioner's "Compensation"	£1,000
Propagation of food-fishes	30,000
Distribution of food-fishes	10,000
Maintenance of vessels	10,780
Inquiry respecting food-fishes	4000
Statistical inquiry	4000
	£59,780

During the two years the Commission steamer "Albatross" was engaged in surveying the fishing-grounds off the Pacific coast of the United States, her work extending along the coasts of Washington, Oregon, and California, and over the shallow water area in the eastern part of the Behring Sea. In the early part of 1891 the "Albatross" was lent to Professor Alexander Agassiz for the purpose of a biological and physical exploration of the ocean and continental slope between the Galapages Islands on the south and the Gulf of California to the north, a region which had previously been but little examined. This expedition was very successful, important and extensive information having been obtained by its means. The results of the ordinary work of the "Albatross" on the Pacific coast are described in Lieut.-Commander Tanner's special report among the appendices in this volume.

On the Atlantic coast the chief operations were conducted in the interest of the oyster industry. A complete survey was made of the coast waters of South Carolina, where the oysters were found to be all of the raccoon type, forming narrow ledges along the borders of the bays and the winding tidal channels between high and low water. It is suggested that the absence of oysters from the bottom below low water mark is due to the high specific gravity of the water, which prevents the spat from sinking below the surface. The raccoon oysters are useful as seed, improving in shape and flavour when transplanted. The investigation to which the Commissioner here refers has been fully described in two elaborate papers by John D. Battle and Bashford Dean, published in the Bulletin, vol. x, in 1892. Mr. Battle's paper contains the results of the hydrographic survey, and is illustrated by a number of charts showing the details of the observations made; while Mr. Dean describes the physical and biological conditions affecting the life of the oyster. The Commissioner next mentions an investigation in the "Fishhawk" of the oyster beds of Maryland and Virginia in Chesapeake Bay, and of the beds in Long Island Sound. He refers to the journey of Mr. Bashford Dean to Europe, undertaken for the purpose of studying the oyster industry in European countries. Many in this country who are interested in oyster-culture are well acquainted with the lucid and valuable papers in which Mr. Dean has published his observations, namely, *The Present Methods of Oyster Culture in France,* published in the Bulletin, vol. x, 1892, illustrated with ten plates of figures more or less satisfactorily reproduced from photographs of actual scenes; and *Report on the European Methods of Oyster-culture* in vol. xi, 1893, of the Bulletin, still more completely illustrated. These two papers form the best account extant of the methods now practised and the present condition of oyster-culture in Europe. Mr. Dean was sent at the expense of the United States Fish Commission for the benefit of American oyster growers, but European and especially English people interested in the oyster industry are likely to obtain still more advantage and benefit from his careful work than Mr. Dean's own countrymen, and we owe a debt of gratitude to the Commission for thus providing us with reliable and important information without any cost or trouble to ourselves.

In reference to the Wood's Holl station the Commissioner reports that Dr. H. V. Wilson was appointed resident naturalist on behalf of the Commission in 1889, and served in that capacity in the two following years. His researches related chiefly to the development of the sea-bass, cod, and Atlantic salmon. An elaborate paper on the *Embryology of the Sea-bass* by Dr. Wilson is contained in the Bulletin, vol. ix, 1891. The study of the lobster was taken up at Wood's Holl by Prof. F. H. Herrick, and experiments in artificial propagation were conducted by Mr. V. N. Edwards. We are told that the investigations of the latter have furnished conclusive proof that the hatching work of the Fish Commission has been exceptionally successful in increasing the supply of cod on the southern New England coast, and shows that the larger fish resulting from these plantings will to some extent enter more shallow waters than are generally frequented by the cod, shoals of this species now often making their appearance in places where they were never seen before. The evidence for this would be interesting, and we shall see whether it is forthcoming among the documents published by the Commission.

The Report next mentions the investigations of the interior waters of several of the States, which were extensively and systematically carried out, and reports on which have appeared. A brief notice is then given of the inquiry into the methods and statistics of the fisheries, on which a special report is included in the volume. The rest of the Commissioner's Report is on the Department of Fish Culture which is under the chief's immediate direction. Twenty-two stations were in operation in 1890 and 1891. Sea fish were only manipulated at two stations, namely, Gloucester, Mass., and Wood's Holl, Mass., but in addition a few eggs of Spanish mackerel were hatched on the "Fishhawk" in 1891. The eggs of the cod were hatched in the largest numbers, namely, in round numbers 19 millions at Gloucester, 36 millions at Wood's Holl in 1891; at the same station in that year were hatched 3 million flat-fish fry and 3 million lobsters. The shad was still the fish most extensively treated in the operations of the Commission, nearly 70 million fry having been furnished for distribution in 1891. Altogether the number of different kinds of fish artificially propagated was thirty-eight, of which ten were marine, the rest fresh-water or anadromous.

On the interesting question of the benefits produced by the practice the Commissioner says that the results obtained have been difficult of exact determination; that good has followed is shown by the continued increase in the value of the fisheries demonstrated by carefully collected statistics. He urges that in cases where species have been introduced into waters from which they were naturally absent it is clearly shown what is possible of accomplishment, referring to the results of the importation of shad and striped bass to the Pacific coast, and of trout and white fish into streams and lakes of the Yellowstone National Park, formerly barren of food-fish.

We may turn at this point from the Report of the Commissioner to the Report on Statistics by Hugh M. Smith, M.D., in order to ascertain if we can obtain a more quantitative estimate of the results of the piscicultural operations. Concerning the shad we find it stated that this fish has become distributed along the entire Pacific coast north of Monterey Bay, California, and occurs in special abundance in the Sacramento River. Notwithstanding the fact that the fishermen have provided themselves with no apparatus especially adapted to the capture of shad, 101,071 pounds were taken in 1888, and 170,500 pounds in 1889. We are told that the quantity caught affords no idea of the abundance of the fish, and it is thought that the use of suitable apparatus will demonstrate the existence of large bodies of these fish in all the coast waters between Southern California and Puget Sound. But nevertheless it naturally occurs to the reader to wonder what proportion the amount captured on the Pacific coast bears to that taken on the Atlantic. This curiosity cannot be satisfied out of this Report. After some search we discover the statement that $482,403 was the value of the shad taken on the South Atlantic division of the coast of the United States in 1890, but this is not enough to enable one to make a comparison. There is, however, a lengthy and detailed paper on the Fisheries of the Pacific Coast in the Commissioner's Report for 1888, published 1892, and in this we find that the value of the shad captured on that coast in 1888 was $7063, which shows that although the shad has certainly been successfully introduced, the value of the yield on the Pacific side was only $\frac{1}{69}$ of that of the South Atlantic States. Planting of shad on the Pacific slope was apparently commenced in the Sacramento River in 1880. The striped bass (*Roccus lineatus*), though introduced some years before the shad, is stated to be less abundant and less widely distributed than the latter. It was chiefly found in San Francisco Bay, where specimens as much as 40 lbs. in weight have been taken, although the average weight is only 8 or 10 lbs. In 1888 only about 1000 lbs. reached the San Francisco market, but in 1889 they were more plentiful. This is all the statistical information supplied. It is evident enough that these two species have been introduced to the Pacific coast by transporting the fry in railroad cars from the Atlantic side, and the fact is impressive as an illustration of the magnitude of the operations carried on by the Commission. Whatever its imperfections, it has made itself a pisci-cultural organisation which connects together the two greatest oceans of the globe. The transport of useful animals or plants from one continent to another across the ocean is a practice of considerable antiquity; the transportation of valuable fish from one ocean to another across a whole continent had never been accomplished before.

But the question still remains, is there any good evidence by which to estimate the practical results of the piscicultural operations in connection with long-established fisheries? We naturally here examine first the case of the shad fishery on the Atlantic side, since we know that artificial propagation of the shad (*Clupea sapidissima*) has been more extensively and more successfully carried out by the Commission than that of any other fish. We look to see what the Commission has to say of the condition of the fishery. We know that the United States administration does not attempt to supply annual statistics of the fisheries as our own Fisheries Department does. The Commissioner remarks that the limited appropriation and consequent smallness of the force available for statistical inquiry preclude the possibility of an annual investigation; and that even if this were attempted it is open to question whether the variations in the fisheries from year to year are generally sufficiently marked, or whether at this time the results would be of sufficient importance to warrant the largely increased expenditure that would be required to conduct the work. He thinks that comparative statistics are more valuable when they relate to definite intervals of time than when they cover successive years. He asserts that the researches of the Commission furnish data for the comparison of conditions at intervals of three or four years, and for the determination of the influences of the methods and means employed upon the prosperity of the fisheries.

In the Statistical Report the total produce of the shad fisheries in different periods is not definitely presented, but there is a very interesting account of the fishery in the Potomac River, of which the following are the most important points. In 1890, 731,453 fish were taken, weighing 2,571,002 lbs., and realising to the fishermen $75,935, or about £15,200. In 1889, 868,900 fish were taken, valued at $85,378. These figures are compared with those corresponding for the end of the previous decade, namely, less than 200,000 fish in 1878, increasing till 1880, when 600,000 was the number of the season's catch. It will be seen that the increase since 1880, though important, is not enormous, though presumably the Commission claims that the maintenance of the fishery in a prosperous condition is due to artificial propagation. The total value of the shad caught on the South Atlantic coast is given as $482,403 in 1890, but no means of comparing this with any other time are afforded. However, we are informed in the volume that the work of this department was directed by Captain J. W. Collins, while the preparation of the report devolved upon Dr. Hugh M. Smith, in consequence of the fact that Captain Collins was called upon to do special work at the Chicago Exhibition. In the preceding volume of the series, the Commissioner's Report for 1888, there is a much more complete and detailed statistical review, prepared under the direction of Captain Collins, and covering the years 1887 and 1888. This paper contains a large number of very instructive and ably arranged tables, giving the kind of information we have been seeking.

One of these tables give a comparative statement of the catch of shad in all the United States in the years 1880 and 1888. The total catch in pounds in 1880 was 18,074,534, valued at $995,790; while in 1888 it was 35,736,385 pounds, valued at $1,672,192. Thus the amount of the catch had nearly doubled, while the value had not increased in proportion,—that is to say, the price had fallen. The total value in English money is £334,438, which is a little more than the total value of the mackerel landed on the English and Welsh coasts in 1893 (£302,516), but not half the total value of the plaice landed on the same coasts in the same year. The comparison, however, is scarcely just, because the shad is not a true sea fish, but anadromous. It is a curious thing that in another table, showing the comparison by sections, it is shown that the shad fishery in the New England States has decreased from 2,117,392 lbs. in 1880 to 1,412,945 lbs. in 1888. I can find no discussion of this decrease, but it is pointed out in the text of the paper that the total catch of alewives (*Clupea vernalis*) has not increased nearly so much as that of the shad, and that the alewife is not artificially propagated.

It has frequently been supposed that complete statistics of the fisheries of the United States have not been prepared or published. It is true, as we have already seen, that complete annual returns are not supplied; but statistics were compiled for the year 1880, and we have a complete estimate in this paper for 1888. The total value of the coast fisheries is computed to be $35,222,929, or in English money £7,338,110. This is somewhat more than the total value of the products of the fisheries of the United Kingdom in the year 1888 as computed at the Board of Trade, the sum given being £6,418,000. But it must be noted that the American total includes over a million dollars for the whale and porpoise fisheries, and nearly two millions for the seal, walrus, and sea-otter fisheries, as well as $167,000 for reptilian fisheries, while the English returns include no air-breathing animals. Thus it is evident that if we compare the yield of fish, molluscs, and crustacea only in the two countries the fisheries of the United Kingdom are nearly equal in value to those of the United States. Comparing the number of the population employed in the fisheries in the two countries, we find the total in the United Kingdom in 1888 to be 122,526, and that in the United States 137,446; but the latter includes 28,867 shoresmen and factory hands, which ought to be deducted, leaving 108,579. A comparison of the vessels and boats employed in the industry in the two countries seems not to be possible without further explanation of the methods in which the computations are made. According to the United States return, there were in that country in 1888, 6099 fishing vessels, of a net tonnage of 170,126, and in addition 47,195 boats. The number of boats alone, apart from the vessels, is therefore greatly in excess of the total number of fishing vessels and boats of all classes registered under the Act of 1868 in the United Kingdom, namely, 27,812.

We may next pursue our inquiries concerning the results of the operations of the Commission, and ascertain whether evidence as complete as in the case of the shad is supplied with regard to other species, and whether it supports conclusions of the same favorable nature concerning the influence of artificial propagation. At the end of Dr. Smith's report on statistics in the volume for 1889 to 1891 it is stated that the fishermen of the southern New England coast have been much surprised, as well as pecuniarily benefited, by the appearance of young cod in great abundance on grounds where the fish have been scarce or absent for years. The fishery began in 1889, when a few small vessels made good fares, one schooner landing 300,000 lbs. of the fish. Inquiries conducted by the Commission showed that in 1890 by the last of July about 4,000,000 lbs. of small and medium-sized cod were taken in the inshore waters of southern New England, which even the most sceptical fishermen were willing to acknowledge were fish that had been artificially propagated at the Government hatcheries at Wood's Holl and Gloucester. As a result of this single fishery over $100,000 was added to the income of the fishermen, and there was reason to believe that a permanent summer fishery had been inaugurated that promised good returns.

It would, of course, be desirable to have the complete statistics of the New England cod fishery in order to critically examine this statement about the increased abundance of cod. Acknowledgments by the most sceptical fishermen are not in themselves conclusive. We find that the cod is the most important single species in the New England fisheries, the total catch in 1889 amounting to 97 million pounds, valued at 2½ million dollars. But it appears that this fishery is carried on chiefly on the banks east of 65° W. long. It might be suggested that the inshore cod in question migrated in from the banks, but on the whole the probability seems to be on the side of the Commission, which regards these cod as its own production. It is interesting to ascertain the extent of the propagation of cod in the years preceding 1890. The number of fry produced were—

			Totals.
1889.	Gloucester . .	11,000,000	
	Wood's Holl .	8,000,000	
			19,000,000.
1888.	Gloucester . .	627,040	
	Wood's Holl .	8,843,600	
			9,470,640.
1887. 1886.	Wood's Holl .	20,000,000	20,000,000.

The number of cod eggs hatched increased in 1890 and 1891; in the former year it was 21 millions, in the latter 55 millions. The pelagic eggs of marine fishes are still hatched by the officers of the Commission in the Chester tidal boxes and the improved McDonald tidal boxes. No mention is made of any attempt to test the efficiency of apparatus which has been found so much more satisfactory in Europe,—for instance, the Dannevig hatching box, or the hatching jars arranged on the plan used in our Laboratory at Plymouth. At Wood's Holl lobster eggs were stripped from the berried females, and also treated in the Chester and McDonald apparatus and in the universal hatching jar, the total number taken being 8,317,600, and the production of fry 54 per cent. The fry were released when two to four days old, except a few which were kept in the jars for six weeks. A fuller account of this experiment is contained in Mr. Rathbun's report on Food-fishes and Fishing Grounds, from which it appears that the Americans have found the problem of rearing lobster larvæ as difficult as we at Plymouth. It is stated that in none of the trials did more than a small percentage survive for any considerable length of time. Specimens about one month old were taken at the surface in Wood's Holl Harbour, how many or how frequently is not stated; in England the capture of pelagic lobsters is very rare. The stomachs of these specimens contained fragments of Copepods and of the larval stages of crabs, so that their natural food appeared to be other pelagic crustacea. As at Plymouth, it was found that they would eat almost any animal food, from hard-boiled eggs to their own fellows, and rapidly gorged themselves, after which the majority soon died.

Among special observations and experiments described in Mr. Rathburn's report we have it stated that Mr. V. N. Edwards has studied the spawning and hatching of *Pseudo pleuronectes americanus*, the flat-fish or winter flounder, and has discovered that the eggs of this species are adhesive and sink in sea water. The best method of handling them was found to be to spread them thinly on panes of glass and place them in a current of water in the hatching boxes! It seems scarcely credible that any species of the Pleuronectidæ should not have buoyant pelagic ova. But the statements seem to leave no room for doubt, as Mr. Edwards is represented as squeezing the eggs from the fish and hatching them with facility; it is even stated that occasionally adhesion occurs among the eggs in the ovary, which when pressure is applied come out in a solid mass. It was an unexpected fact that the eggs of the sprat and pilchard are pelagic, while those of the herring are adhesive; and now we have a surprise in the opposite direction in the discovery of adhesive eggs in a flat-fish. The mere statement, however, requires to be supplemented, as doubtless it will be in time, by a description with figures by the original observer. Alex. Agassiz and Whitman in 1885 attributed a certain pelagic egg to this species, but apparently they were mistaken. The eggs of *Pleuronectes maculatus* and *Paralichthys oblongus* were obtained at Wood's Holl by Mr. Edwards, and were buoyant.

It had generally been believed that the American oyster, *Ostrea virginica,* did not reproduce itself in San Francisco Bay, where large numbers of seed or yearling oysters brought over from the Atlantic coast are reared for the market. Mr. Townsend, naturalist of the steamer "Albatross," has, however, found in several parts of the bay, Atlantic oysters naturally spatted and derived from parents on the planted beds in such conditions—*e. g.* attached to rocks and piles—as left no doubt that they had developed from free spat *in situ.* Mr. Rathbun's report gives a fuller account of the oyster investigations referred to by the Commissioner himself. It is to be hoped that the efforts of the Commission will succeed in improving the condition of the oyster industry on the Atlantic coast, for the statistical review in the Report for 1888, already frequently referred to, shows that a serious deterioration had taken place between 1880 and 1888. The total decrease in bushels was from 22,195,915 to 21,765,640, made up as follows. The production in the New England States had increased enormously—more than doubled, in fact; in the Gulf States it was nearly four times as great in 1888 as in 1880, and there was also an increase in the Pacific States and in the South Atlantic

States. But a large proportion of the total production was derived from the Middle Atlantic States, which may be regarded as the chief original source of American oysters, and this quantity had decreased from 20 million to 17 million bushels.

In conclusion we may refer to the account in the Commissioner's particular report of an investigation, by the United States Senate, of certain charges brought against the administration of the Commission,—charges of want of discipline, inefficiency, and corruption. A committee of the Senate thoroughly inquired into the charges, and found none of them to be established, but decided from the evidence that the Commission was properly administered, and was performing valuable work worthy of its cost to the State. On this result all who know anything of the Commission will heartily congratulate it and its energetic chief, Colonel McDonald.

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Experiments and Observations made at the Plymouth Laboratory.

By

J. T. Cunningham, M.A.

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I. Diagnostic Characters in Flat Fishes.

One of the objects of zoological study is to ascertain more completely and more accurately the peculiarities by which one kind of animal (species, variety, genus, &c.) is distinguished from another. The advance of our knowledge in this direction depends on the more minute examination and more accurate distinction of known forms, the examination of larger numbers of specimens from familiar localities, and the examination of specimens from localities previously unsearched. There is scarcely any family so thoroughly investigated that it does not yield new discoveries on a renewed examination of more abundant material. It is found possible to recognise finer distinctions, and so split up one species into several, or convert what was considered a species into a genus. New material—that is to say, examination of a large number of specimens—often shows, too, that distinct species are more or less connected by intermediate forms. But in all this work the part played by these minute peculiarities in the life of the animal usually receives little attention. It is not the object of systematic zoology to ascertain the uses of characters, or to explain their origin. These objects require different methods, and are usually pursued by different investigators. But among the various methods employed there is one which has seldom, if ever, been followed—that of surveying the various characters of different grades,—specific, generic, family, &c. —in order to find whether it is possible to trace a connection between them and the habits of the animals which exhibit them, and generally to consider how far the principles which have been suggested in explanation of the evolution of species are applicable to the diagnostic characters of a particular family. On the present occasion I propose to consider the family of flat fishes. This Journal is, I think, not the place for a paper entirely devoted to developing arguments or presenting evidence in support of particular views or conclusions of a theoretical character. Therefore, although my inclination to certain views may be obvious in the following remarks, I have no desire to press these views on this occasion; but my object is merely to describe certain observations and studies I have recently made, and to point out what an immense field of interesting inquiry is afforded in the relations and development of those characters by which the subdivisions of a single family of fishes are distinguished.

My own observations have been for the most part confined to British specimens of the family of flat fishes; and for a general survey of the characters throughout the family, and their relations to one another, I shall rely chiefly on a valuable paper by the American ichthyologists, Jordan and Goss, published in 1889.* Certain kinds of flat-fish are distinguished by the fact that the dorsal and ventral fins are prolonged on to the lower side of the body at the base of the tail, the attachments of these accessory portions being transverse to the axis of the body. One of the fish that present this character is not uncommon round all the coasts of Britain; at Plymouth specimens are frequently obtained, either in the Sound in summer, or on more distant grounds. This is the *Zeugopterus punctatus* of Collett, the *Muller's topknot* of Couch, *Rhombus hirtus* of Yarrell. The chief other characteristics of this fish are its almost rectangular shape, the posterior region of the body being much broader and less triangular than in other flat fishes, the roughness of the upper side of the body, due to the character of the scales, and the presence of a large foramen in the septum between the gill-cavities. The great breadth of the body posteriorly is due partly to the breadth of the body proper, partly to that of the dorsal and ventral fins, in which the fin-rays are longest near the posterior end, so that the outer edges of the fins form a straight line transversely across the base of the tail. The snout is obtuse, and the trunk and dorsal fin rise steeply behind it, giving the rectangular form anteriorly. The scales are short from before backwards and broad transversely; the exposed portion is short, and projects outwards from the skin at an angle with the embedded portion; at the edge is a single row of spines, of which the central one is considerably the longest. These spines are not of the same length in all the scales, but longer ones occur at scattered points over the skin.

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* *A Review of the Flounders and Soles (Pleuronectidæ) of America and Europe*, by David Starr Jordan and David Kop Goss; Rep. U.S. Fish Commission for 1886 (1889).

Only two other kinds of flat fishes are known in which what may be called subcaudal finlets are present; or, to put the same fact in other words, the fishes in which this character is present are separated by other differences into three species. The other two are *Zeugopterus unimaculatus,* Steenstrup, and *Zeugopterus norvegicus* (Günther). The former is distinguished by the fact that the first ray of the dorsal fin is produced into an elongated filament, while in the latter this character is wanting, and the pelvic fins are separate from the ventral, not united with it as in *punctatus.* The other specific characters consist in minor differences in the generic characters themselves. The perforation of the branchial septum exists also in *Arnoglossus megastoma,* commonly called the megrim at Plymouth; and in consequence of this Steenstrup included this species with the three previously mentioned in the genus Zeugopterus. But as this last species does not possess the subcaudal prolongations of the dorsal and ventral fins, nor the other characters which unite the first three, it is best to confine the name Zeugopterus to these three species.

The three species of Zeugopterus, then, have what may be described as a continuous distribution. No two of them are geographically separated, and they have not been found anywhere beyond a limited region on the coast of Europe. All three occur on the British coasts. *Punctatus* is, as has been stated, frequently taken in Plymouth Sound; it occurs all along the south coast of England, and also on the east coast. It has been taken on the east coast of Scotland as far north as the Orkneys, on the west coast of Scotland in the Firth of Clyde, and on the east coast of Ireland. Northward the species extends to the north coast of Norway, southward to the northern shores of France, but it is absent from the Mediterranean. *Norvegicus* is likewise a northern form, not ranging to the Mediterranean. I have taken several specimens at Plymouth: one specimen was taken during the survey of fishing grounds on the west coast of Ireland, 1891–2; three specimens have been taken in the Clyde. It is somewhat rare on the Scandinavian coasts. *Unimaculatus,* on the other hand, is a Mediterranean form, occasionally but rarely taken on British and northern coasts. I have never obtained a specimen at Plymouth. On the south-west coast of Scotland it is more abundant than at any other part of the British coasts, several specimens having been taken in Loch Fyne and the Firth of Clyde. It has been taken on the coast of Denmark, but not on that of Norway.

Peculiar habits, differing from those of other flat fishes, have been observed in living specimens of two species of Zeugopterus, namely, *punctatus* and *unimaculatus.* The fish are seen in aquaria to be nearly always adhering to the vertical sides, remaining in one place for a long time, and keeping themselves suspended in this way in a vertical position without any difficulty. Other flat fishes occasionally assume this position, but are unable to retain it for more than a few seconds or minutes. This habit was studied by the late Mr. George Brook, F.Z.S., who described his observations in two papers.* In the first of these he refers only to *Zeugopterus unimaculatus,* of which he took several specimens in Loch Fyne in a small sandy bay. They usually adhered to the sides of the tank in which they were placed, although found on this sandy ground overgrown with Zostera or sea-grass. The body was slightly raised from the glass with the lower surface of the unpaired fins tightly pressed against it. A current of water is stated to have passed from the branchial chamber of the lower side along the space between the body and the glass and out behind, this current being caused by a rapid vibratory movement of the accessory portions of the dorsal and anal fins. The accessory portions of the fins appeared, therefore, "to be specially constructed to aid in the respiratory function." In his later paper Brook states that he was inclined to think he laid too much stress on the action of the accessory flap. "The basal portions of the vertical fins are kept in constant motion, but this motion is more vigorous in the rays immediately in front of the tail than in the accessory flaps situated underneath it." Brook did not attempt to explain the method by which the fish was enabled to adhere to the glass or other vertical surface and maintain itself in a vertical position.

My own observations in the Plymouth Laboratory have been made on *Z. punctatus,* and my object was to ascertain what force kept the fish in a vertical position against a vertical surface, and how the force was produced. The fish lives well in confinement, and is not timid or violent in its movements when disturbed. It is not difficult, therefore, to guide it to the glass front of the tank and persuade it to adhere there, so that observations and experiments can be made with it. It was evident that the adhesion of the fish was not produced by ordinary sucker action—in other words, by hydrostatic pressure, because the space beneath the body was freely open to the outside water in front dorsally and ventrally to the head. The posterior parts of the fin-fringes were in constant motion, moving in a series of vibrations from before backwards, together with the part of the body to which they were attached, and the effect of this motion was to pump out the water from the space between the body and the glass, its place being supplied by water which entered in front. The subcaudal fin-flaps were perfectly motionless, and tightly pressed between the base of the tail and the surface of the glass, so that any movement of them was impossible. The question arose, however, whether the tail and these flaps formed a small sucker which helped in the adhesion. To test this I removed the flaps with a snip of the scissors, an operation which caused very little pain to the fish, and it adhered afterwards quite as well as when the flaps were in their natural condition. The subcaudal flaps are therefore certainly not necessary to the adhesion, nor to the pumping action of the muscles and fins, which went on as before. It seemed probable, therefore, that the pumping action was itself the cause of the adhesion. But the difficulty in accepting this view was that there was a distinct though gentle respiratory movement of the jaws and opercular flaps ; and if the pumping of the water from beneath the body caused a negative pressure there, and a positive pressure on the outer side of the body, it seemed equally certain that the respiratory movement must force water into the space beneath the body, and so cause a positive pressure there which would tend to force the fish away from the glass. The currents of water were now examined by means of the suspended particles in the water, and by putting carmine from a pipette at any spot at which it was desired to see the rapidity and direction of the flow. Particles were seen to pass in at the mouth and out at the lower respiratory orifice, but particles and carmine were also seen to pass into the space beneath the body above and below the head without passing through the respiratory channel. It was, therefore, satisfactorily proved that the amount of water pumped out in a given time at the sides of the tail was greater than the amount passed in anteriorly by the respiratory movements; and considerably greater, for the velocity of the stream above and below the snout as shown by the movement of the particles of carmine was by no means insignificant. It follows that the pumping action of the fins, continually withdrawing water from the space between the body and the surface to which it is applied, causes a negative pressure greater than the positive pressure due to the respiratory movements, and this keeps the body pressed against the vertical surface sufficiently to prevent its falling. The negative pressure is continually being neutralised by the water entering in front, and therefore the pumping action must be constantly kept up, as it is observed to be.

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* *Ichthyological Notes,* Fourth Ann. Rep. Scot. Fishery Board; *Notes on the British Species of Zeugopterus,* Proc. Roy. Phys. Soc. Edinb., Session 1886–7.

The direct resistance which prevents the fish from falling under the action of gravity is, of course, friction; but unless there was some force to press the fish against the solid surface there would be no friction. In testing the currents with carmine it was seen to pass in at the mouth and out at both gill openings and nothing was observed which indicated a special part played by the perforation of the gill-septum.

To test the validity of the explanation I had arrived at concerning the adhesion of the fish, I constructed a model in the following manner. I took a rectangular piece of flexible thin sheet india rubber. In the middle of each of the shorter sides I fastened, by a few stitches of sewing cotton, a short piece of glass tubing. On to one of these pieces I adjusted a long piece of rubber tubing. I placed the apparatus in a tank, bringing the tubing out over the edge of the glass front, and allowing it to act as a siphon, drawing water out of the tank. While the siphon was running I placed the india-rubber flap gently against the glass inside the tank under water, and it remained adhering to the surface. The front piece of glass tube now represented the respiratory channel of the fish, and above and below it were apertures between the front of the tank and the rubber flap, representing the apertures above and below the snout in the case of the fish. The action of the siphon represented the pumping action of the muscles and fins in the fish. There was nothing in the model to represent the respiratory movements of the fish, but that does not invalidate the comparison. When the siphon was stopped by pinching the rubber tubing outside the tank, the rubber flap fell away from the glass and sank slowly to the bottom of the tank. I think with this confirmation the evidence I have now given in support of my explanation of the adhesion of the fish to vertical surfaces is amply sufficient. I have observed that when other kinds of flat-fish cling to the vertical surface of the glass front of an aquarium they move the posterior parts of the unpaired fins in the same way as Zeugopterus, but these parts of the fins and the muscles adjacent being less developed, the action is neither so powerful nor so long maintained.

There can be little doubt that the explanation above given applies to *Z. unimaculatus,* in which the habit of adhesion was observed by Brook, as well as to *Z. punctatus.* It probably applies also to *Z. norvegicus,* but I have not yet ascertained whether this species has the same habit. We do not know at present whether there are any other important differences in mode of life between Zeugopterus and other genera,—such, for instance, as kind of food. We know that these flat fishes are not entirely confined to rocks, but are also found on sandy bottoms with other flat fishes. There is no doubt that when adhering to a rock, one of these fishes accommodating its colour to that of the rock surface is well concealed from observation, and in this way its habit is an advantage to it, just as the habit of covering itself with sand is of advantage to a sole. But according to the present state of our knowledge the only generic character which is necessary to the peculiar habit is the great development of the posterior muscles and fins, which is the chief factor in the characteristic shape of the body. It is possible that the roughness of the upper surface, due to the spines of the scales, adds to the concealment of the fish by aiding in the resemblance to a rock surface. But no use has yet been found for the subcaudal prolongations of the fins or the perforation of the gill-septum.

With regard to the specific characters, nothing is known of peculiarities in mode of life which would give an importance in the struggle for existence to the concrescence of the pelvic fins with the ventral in *punctatus,* to the absence of this character and the elongation of the first dorsal ray in *unimaculatus,* or to the absence of both characters in *norvegicus.* No use is known, in fact, for any of the other specific characters, of which a brief review may be here given. The characters tend to form a series. Thus, in size, *norvegicus* is smallest, *unimaculatus* larger, and *punctatus* largest, the last reaching a length of 8½ inches. The subcaudal fin-flaps are least developed in *norvegicus ;* most in *punctatus ;* each has four rays in *norvegicus* and *unimaculatus,* six in *punctatus.* The shortening and spinulation of the scales are greatest in *punctatus,* least in *norvegicus.* In *punctatus* there are teeth on the vomer, in *unimaculatus* none, in *norvegicus* they are very small.

According to the studies of Jordan and Goss, the flat fishes form three well-marked sub-families, including the most numerous and important forms, and sundry other sub-families of less importance. These three are those whose familiar British representatives are the turbot, the plaice, and the sole; they may be called the Rhombinæ, Pleuronectinæ, and Soleinæ. I do not follow the American authors in their application of the names. The Rhombinæ have the following principal distinguishing characteristics.

The body is sinistral. The mouth is symmetrical, the dentition nearly equally developed on both sides, and the teeth acute. Pectorals and pelvics usually well developed, and the pelvics asymmetrical, that of the left or eyed side inserted on the extreme edge of the abdomen, its rays more or less wide apart; that of the right side inserted on the right side. Caudal fin rounded or subtruncate. Vertebræ in moderate or small number. Species chiefly tropical or subtropical.

It is to this division that Zeugopterus belongs. The nearest relative of Zeugopterus is certainly the megrim, which has the perforation in the gill-septum. This fish was united with Zeugopterus by Steenstrup, with Arnoglossus by Day. Günther places it as a sub-genus of Rhombus, with the name Lepidorhombus, and in my opinion it is best to separate it altogether under this name. The only other species of the genus is *Lepidorhombus Boscii.* I do not know whether the latter has a perforated gill-septum, but think it probable. The chief characters of Lepidorhombus are the very large mouth, thin body, and skin with little pigment and ciliated deciduous scales. *Citharus linguatula*, Günther, closely resembles the megrim, but has unequal teeth, and is destitute of the perforation of the gill-septum. Arnoglossus is a fairly well-marked genus, of which several species have been described, but only two (*laterna* and *Grohmanni*) are definitely known to myself. The scales are small and feebly ciliated, very deciduous, the skin also being very thin and weak, so that it is easily torn and detached. The mouth is comparatively small, much smaller than in Lepidorhombus. The fish are of somewhat small size. The presence of secondary sexual characters must be regarded as characteristic of this genus, some of the anterior median fin-rays being elongated in the male. All these forms are confined to the coast of Europe. Two species from deep water in the Gulf of Mexico have been assigned to Arnoglossus, but there is little probability that they rightly belong to it.

Rhombus is a genus which is distinct from all those above mentioned. It has a broad, usually strong body, with a thick skin; a broad interorbital area, whereas in the preceding forms it is narrow, and scales small, cycloid, or wanting. The mouth is large and the jaws strong; the teeth small, in bands, and nearly equal. The specific differences consist chiefly in the character of the dermal armature. In the brill (*Rhombus lævis*) the scales are cycloid and imbricate on both sides of the body, and there are no bony tubercles; the anterior rays of the dorsal are somewhat prolonged and much branched. In the turbot (*Rhombus maximus*) there are no scales, but bony tubercles scattered over the upper surface, absent on the lower; and the anterior dorsal rays are not prolonged, or distinguished in any way. These two are confined to Europe; on the American coast of the Atlantic there is a species resembling the brill called *R. maculatus*, known commonly as the window-pane, from its thinness. It is scaled on both sides, and the anterior rays are more prolonged than in the European brill. Transitional forms between the brill and the turbot have long been known, and were originally described as a separate species under the name *R. mœoticus* by Pallas in Zoogr. Ross. As. in 1811. Specimens from the Black Sea have been frequently described since, and they seem to be more abundant there than elsewhere. Steindachner (Ichth. Berichte, 1868) states that a complete series of gradations between the ordinary turbot, in which the scales are obsolete, and the scaly turbot, which is more or less completely scaly, is to be observed. He obtained one of the most completely scaled specimens from the Baltic. Whether these specimens are to be regarded as variations, a variety, or as hybrids, we do not know. If they breed true, so that a scaled specimen is derived from scaly parents, then they form a variety, but this seems unlikely; it seems more probable that scaled forms occasionally develop from ordinary parents.

Another interesting genus in the Rhombinæ closely allied to Rhombus is Rhomboidichthys, called Platophrys by Jordan and Goss. In this genus the scales are small and ctenoid, and not deciduous. The interorbital space is very broad, and the peculiar position of the dorsal eye gives a curious appearance to the fish. There is a slight difference between the sexes, the pectoral of the left or upper side being filamentous in the male. Many species have been described from the West Indies and east coast of South America, and one from the Pacific coast.

It is unnecessary at present to refer to any of the remaining genera or species of the Rhombinæ which are less known. The principal characters by which the best known forms are distinguished have been mentioned, and what do we know of the functions of those characters? No one has hitherto been able to suggest a reason why the scales are more useful to the brill and tubercles to the turbot. We do not know why the male Arnoglossus requires elongated fin-rays, a kind of piscine moustache, a masculine ornament which is developed in several other species of fish. We can say with truth that the Rhombinæ are for the most part predaceous flat fishes which seize active prey, and to this habit of life the large symmetrically developed mouth and teeth are adapted. It is quite possible, too, that if we knew the habits of particular species more exactly and more completely, we should see that the whole muscular system and shape of body, as well as the particular size of mouth, were adapted to the particular habits and surroundings. But this leaves some of the features most important in diagnosis, such as the scales and the secondary sexual characters, unexplained.

A different set of characters offering similar difficulties occurs in the sub-family Pleuronectinæ. The common features of this sub-family as diagnosed by Jordan and Goss are the following:

Mouth small, asymmetrical, the jaws on the eyed side with nearly straight outline, the bones on the blind side strongly curved; dentition chiefly developed on the blind side; eyes large; edge of pre-opercular not hidden by the scales; pectoral fins well developed;

unpaired fins well separated; pelvic fins nearly or quite symmetrical; body dextral. Species arctic or subarctic in distribution.

In this sub-family Jordan and Goss make our common dab the type of a genus. The characters are—

No accessory branch to the lateral line, but a distinct arch in it over the pectoral.

Scales rough, ctenoid, and imbricated.

Vertebræ forty in number.

The authors recognise four species. One of these is doubtful, founded by Prof. Goode on certain specimens taken in deep water off the southern coast of New England. *Limanda limanda*, the European form, has no rugose prominences above the operculum behind the interorbital ridge. The fin-rays are—dorsal 65 to 78, ventral 50 to 62; scales along the lateral line 86 to 96, teeth in an irregular series. This species extends from the Atlantic coasts of France along all the coasts of Northern Europe, and on the coast of Iceland: it is absent from the Mediterranean.

Limanda ferruginea is the dab of the American side of the Atlantic, extending from New York to Labrador. It differs from ours in having more numerous teeth in a more regular close-set series, a more projecting snout, and rugose prominences above the operculum. The fin-rays are a little more numerous, namely, D. 85, A. 62. The scales are smaller and more numerous, namely, lateral line 100.

Limanda aspera is the dab of the North Pacific. It is distinguished by somewhat marked characters, of which the principal are that there is no angle between the snout and the profile of the head, and the scales of the blind side are more or less rough, those of the upper side rougher than in the other species. Specimens have been taken on the coasts of both Alaska and Kamtschatka. It seems, therefore, that while the species on opposite sides of the Atlantic are different, those on opposite sides of the Pacific are the same. This case offers an instance of geographical races. The differences are not great, but if they are constant it matters little whether we call these forms, species or varieties or races. The case affords a contrast to that of Zeugopterus; in the latter we have three species in the same area, separated by no barriers except those which are physiological: in other words, they do not interbreed. In the case of the three forms of Limanda interbreeding is physically impossible, except where the ranges meet. We have no evidence that the differences are adaptational.

Closely allied to Limanda is a species in the Pacific called by Jordan and Goss *Lepidopsetta bilineata*. Only one species is placed in the genus, the establishment of which seems superfluous. The form is distinguished from Limanda by the presence of an accessory branch of the lateral line, which starts from the anterior portion of that line, extending in all members of the family above the eyes, and runs backward along the base of the dorsal fin. It is a curious fact that this variation is known as a constant character only in the Pacific, and that there it occurs in a large number of species: of the thirteen species of this sub-family in that ocean distinguished by Jordan and Goss it occurs in eight; and it also occurs in one genus, also in the Pacific, in the quite distinct sub-family Hippoglossinæ. A fact of this kind cannot be explained simply as an adaptation; it cannot be supposed that there is some common peculiarity in the habits and surroundings of all these species which renders this particular extension of the lateral line useful.

The plaice (*Pleuronectes platessa*) is distinguished from *P. limanda* by wanting the arch to the lateral line, having cycloid reduced scales and tubercles on the post-ocular ridge. The flounder has differentiated scales, most of them being reduced and cycloid as in the plaice, but those along the bases of the longitudinal fins, along the lateral line, and on the head being enlarged to form rough spiny tubercles. *Pseudo-pleuronectes americanus*, the representative of the plaice on the east coast of America, approaches the dab in having imbricated ctenoid scales. In *Liopsetta Putnami* the spinulation of the scales is a sexual character, the scales in the male being rough and strongly ctenoid, in the female smooth and almost completely cycloid. This species ranges from Cape Cod to Labrador. Mr. Holt, in the last number of the Journal, has described specimens of the plaice from the Baltic in which ciliation or spinulation of the scales, although varying in different individuals, was distinctly a sexual character more strongly developed in the males. Möbius, in his Fishes of the Baltic,* mentions these ciliated plaice, and observes that they form a transition to unusually smooth specimens of the flounder. The smooth flounders, although occurring on the south coast of England, are stated to be commonest in the Mediterranean, where they seem to occur exclusively. It appears, therefore, that there is a northern rough variety of the plaice and a smooth variety of the flounder in the south.

We have at present no evidence that these differences are adaptational, nor can we trace them to preceding or determining causes. But, on the other hand, we must admit adaptation in many of the characters of the sub-family. For instance, the small size and asymmetrical shape of the mouth correspond to the general habit of these fish of feeding on invertebrate slow-moving creatures on the sea bottom. The fish seize their prey from above with the lower side of the jaws. But many of the characters of the sub-family cannot definitely be proved to be adaptive, *e. g.* the narrow symmetrical pelvic fins and the slight anterior extension of the dorsal fin.

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* IV^{te} Bericht der Comm. zur Unters. der Deutschen Meere.

II. THE DEVELOPMENT OF THE EGG IN FLAT FISHES AND PIPE-FISHES.

Since my paper in Vol. III, No. 2, p. 154, of this Journal was written I have been continuing my studies of the development of the eggs in the ovaries of fishes. My attention has been given principally to the history of a definite body in the yolk known as the vitelline nucleus, but quite distinct from the proper nucleus of the egg or germinal vesicle. I hope to be able at some future time to publish a full account of my observations with adequate illustration, but in the meantime some account of the subject in the Journal of the Association may be useful.

In the fresh state it is almost impossible to perceive any trace of the vitelline nucleus, only a faint indication of it can be made out after familiarity with it has been gained by the study of its structure in preparations which have been subjected to the action of reagents. In fishes in which the eggs before the development of yolk are extremely transparent the structure can be easily seen after treatment with dilute acetic acid, in a small portion of the ovary simply spread out on a slide. In those eggs in which the development of yolk has made considerable progress the body in question can only be seen in prepared sections. In a piece of the ovary of a flat-fish in which there is no yolk—for instance, a flounder or plaice,—on the addition of acetic acid the transparent protoplasm of the egg gradually coagulates, and the first change to occur is the appearance of the vitelline body as a spot which is more opaque than the surrounding substance. In the larger ova (Fig. 1, *b*) this body is round and of considerable size, somewhat larger than one of the nucleoli of the germinal vesicle, and it is situated between the germinal vesicle and the surface of the ovum. Examined with a high power it is seen to consist of a spherical collection of minute granules. In the smaller eggs (Fig. 1, *a*) those about ·118 mm. in diameter, the vitelline nucleus is somewhat smaller and close to the surface of the germinal vesicle. In still smaller eggs, only ·10 mm. in diameter, the body can just be discerned as a few granules just outside the membrane of the germinal vesicle, and in ova smaller than this no trace of it is visible. I have not been able to see any indication that the vitelline body is situated on a particular side of the egg. The egg is approximately spherical; the question whether the radius of the sphere which is determined by the presence of the vitelline body has any particular position in the subsequent history of the egg will be considered later.

It will appear, then, that the body in question, judging from examination of entire fresh ova treated with acetic acid, is not present in the youngest ova, but becomes visible when they have reached a certain definite size; that it makes its appearance in the form of a few granules close to the wall of the germinal vesicle, and as the egg becomes larger is gradually more and more separated from the latter, at the same time increasing in size and opacity. This suggests that the body is formed from the germinal vesicle by the expulsion of granules; but no direct evidence of this can be seen, and, moreover, it is not supported by the fact that the vitelline body increases in size after it is separated by a layer of protoplasm from the germinal vesicle. In eggs in which the yolk has begun to appear at the surface of the cell-plasma the vitelline body is seen beneath the layer of yolk granules, and it never actually reaches the surface of the egg.

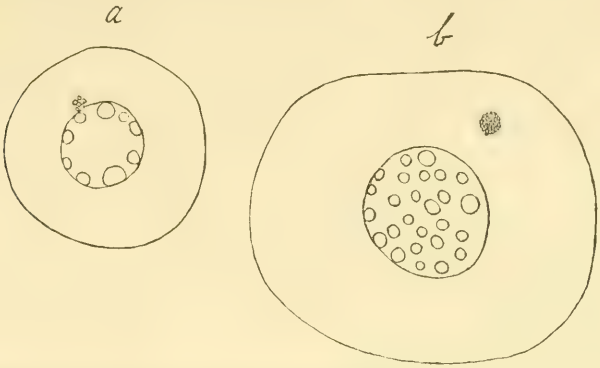

Fig. 1.—Developing eggs from the ovary of a plaice 8¾ inches long, examined August 30th, 1894; treated with dilute acetic acid. Seen with Zeiss E, oc. 3.

After the character of the vitelline body has been studied in ova treated with acetic acid, it is possible sometimes to make it out in living ova without the addition of any reagent. It is seen then as a group of faint granules whose opacity and refringent power are very slightly different from those of the surrounding cell-plasma.

There is, therefore, a stage in the development of the ova in a flat-fish in which neither the vitelline nucleus nor the yolk have appeared or commenced to develop. It would be interesting to have a satisfactory account of the whole history of the ovum, and particularly of this early stage, but at present there are many passages in the history not yet elucidated. In prepared sections of an ovary from an immature fish—for instance, a plaice 7½ inches long killed in March—the youngest ova are seen beneath the surface of the germinal lamellæ. The lamellæ are covered by a very thin membrane containing nuclei. This membrane represents what is known as the germinal epithelium, but it is so thin that it is difficult to see much of it in transverse sections. The smallest ova are rounded, and their germinal vesicle contains one large nucleolus, whose diameter is usually equal to half the diameter of the whole vesicle. This nucleolus is solid and homogeneous, and is darkly stained by staining liquids. In the ova of many animals—for example, Ascidians, Echinoderms, Molluscs—the germinal vesicle remains in this condition, having one large nucleolus until the egg is ripe. In the fish, as the egg gets larger, instead of one a number of nucleoli are developed, which, at first scattered through the reticulum of the vesicle, are subsequently arranged in a single layer in the external region just within the limiting membrane. None of the numerous nucleoli are as large as the original single one, and I believe that the latter subdivides. But I do not think all the new nucleoli are produced by subdivision of the original one, because in the younger and smaller ova there are to be seen very minute nucleolar granules together with a large undiminished nucleolus, so that it is to be inferred that many of the additional nucleoli are produced by the increase in size of these minute granules.

In very young fish none of the ova contain a vitelline nucleus; for instance, in sections from a plaice 3 inches long, killed in March and probably a year old, it is not to be seen. In these sections the largest ova have a diameter of ·07 mm. The production of young ova in this ovary was evidently going on rapidly; nests of them are present at numerous spots in contact with the germinal epithelium. But even at this early stage nuclear division figures are not to be seen, nor have I detected such figures in sections of the ovary at any stage. It may be that even in the young ovary the youngest ova seen have passed beyond the division stage and entered upon the period of growth, and that division only takes place in the flat germ-cells of the epithelium, and cannot be seen in sections. But even when examining the germinal epithelium from the surface I have seen no division figures, nor am I aware that other observers have described any. It is a point which requires further investigation.

In sections from a plaice 7½ inches long, fixed with chromic and osmic acids, the vitelline nucleus is distinctly visible in the larger ova, whose diameter has a maximum of ·14 mm. The appearance of the nucleus is quite different from that of the nucleoli in the germinal vesicle; its outline is not so definite, and it is seen to be a group of refringent granules. It does not stain so deeply as the nucleoli. The younger stages of it described above as seen in fresh preparations are not visible in the sections, but only the later stages in which it is situated near the surface of the ovum.

The vitelline nucleus persists in the ovum during the development of the yolk. To obtain satisfactory sections of the yolked ova, as a rule other reagents must be used than those which succeed best with the ovaries in which yolk has not begun to develop. Picro-sulphuric acid is one of the reagents which give good results. I have some sections prepared with this reagent from a large plaice taken from the aquarium and killed in August. In these many of the smaller yolkless ova are collapsed and shrunken, and the connective tissue between the ova is distended and broken, but the yolked ova are in many cases wonderfully perfect. The stain used was hæmatoxylin, and the yolkless ova are over-stained, but in this respect also the yolked ova are very satisfactory. The yolk forms an external layer of varying thickness according to the size of the egg; and between it and the germinal vesicle is a layer of finely reticulate protoplasm. The vitelline nucleus has a shape which suggests that of an octopus: towards the centre of the egg it is rounded and has a definite outline, although it is not separate from the surrounding protoplasm, but continuous with it. It lies on the inner boundary of the layer of yolk, which consists of small yolk spherules. On the outer side the vitelline nucleus gives off a number of diverging processes which run into the yolk layer, becoming continuous with the protoplasmic strands which separate and enclose the yolk spherules. The substance of the vitelline nucleus is deeply stained (in hæmatoxylin), and in structure is finely granular, not as in the younger stage composed of a small number of refringent granules.

As the thickness of the yolk layer increases it at lasts passes the vitelline nucleus, so that the latter comes to be situated entirely within the yolk-containing layer of the egg, and can be seen as an island of granular protoplasm surrounded by the yolk spherules. In this condition it is not so conspicuous, and is relatively smaller. My preparations showing this stage are from a large plaice killed in August, and the largest eggs in the sections are about ·28 mm. in diameter. In these most advanced eggs there is still a layer of protoplasm containing no yolk between the layer of yolk and the germinal vesicle.

During the development of the yolk the germinal vesicle exhibits changes. The chief of these is that the nucleoli are no longer almost always arranged in a single row at the outside of the vesicle, but are seen scattered in the central regions. In many preparations the membrane or outline of the germinal vesicle is much wrinkled and contracted, but this is to a certain extent due to the action of reagents. It occurs in preparations made with corrosive sublimate and acetic, and with picro-sulphuric acid, but in some preparations made with chrom-osmic acid it is less marked. On the other hand, in a piece of the ovary from a flat fish just killed and placed on a slide beneath the microscope, without the addition of water or any reagent, the wrinkling of the membrane of the germinal vesicle is very frequently observed in the larger transparent ova and in those in which yolk is commencing to develop. It is probable enough, therefore, that this wrinkling of the membrane is, to some extent, a natural phenomenon occurring during life, although there can be no doubt that in many preparations the nucleus has been further altered and contracted by the action of the reagents.

This wrinkling of the membrane is the same condition which is described by Scharff * as the formation of peculiar protuberances all over the outer surface of the germinal vesicle in eggs of the gurnard. His fig. 9 agrees closely with the appearance presented in many of my own preparations. But he gives an extraordinary interpretation of the changes taking place, which I am quite unable to accept.

He states that the protuberances containing nucleoli are separated off, carried towards the exterior of the egg, and there form the yolk spherules, having the appearance of cells containing a nucleus. I am unable to trace any direct connection between nucleoli and yolk spherules. I have failed to find after long and careful scrutiny the slightest evidence that the nucleoli migrate at all. It is true that occasionally a nucleolus in a prepared section appears to be outside the nuclear membrane, but I find this is always due to one or other of two causes; either the nucleolus has been bodily pushed out of its place by the edge of the razor which failed to cut through it immediately, or the pouch of the wrinkled membrane has been cut in such a manner in the section that it is separate from the interior of the main germinal vesicle. In the latter case the connection can be seen in the next section. In the former case the artificial nature of the occurrence is easily proved by observing that the direction in which the nucleolus has moved is the same as that of other striæ in the section caused by the razor. The nucleoli become very hard after the action of chromic acid, and it is in preparations from tissue hardened with this reagent that such dislocations usually occur. The hypothesis that the nucleoli give rise to the yolk spherules is untenable from the nature of the case, for the spherules are very numerous, and as the egg ripens form a bulk

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* Quarterly Journal Micr. Sci., vol. xxviii.

many times greater than the germinal vesicle, or than all the nucleoli put together. There is no indication of a rapid formation of nucleoli, and at the end in the egg almost ripe there are still a number of nucleoli remaining. It is practically certain, therefore, that the yolk spherules are formed *in situ*, first on the outside of the egg and then progressively inwards.

Another point in which I am unable to agree with Scharff's description is his account of the division of the protoplasm of the egg into two layers. In this case again, in my opinion, he has been misled, as many others have been in microscopical researches, by alterations due to method of preparation and the action of reagents. Scharff states that the ovaries from which his sections were prepared were hardened with weak chromic or with picro-sulphuric acid, both excellent reagents which I have largely used myself. But he states that his preserved material was prepared not by himself, but by Professor McIntosh; and it is not certain whether the ovaries were perfectly fresh when preserved—a very important point. My experience is that when preparations are made from fish obtained in the market which have been dead several hours, the preserving liquid used being Perenyi's mixture, a division of the protoplasm into two zones is seen. The ovary when examined fresh appears perfectly unaltered, but after preparation produces a result different from that obtained from an ovary taken from a fish just killed. The outer lighter zone is frequently separated from the inner. In all my successful preparations from ovaries preserved immediately after the death of the fish there is no division of the protoplasm into zones in the yolkless ova, and in the older ova the only distinction is that between the outer layer containing yolk granules or spherules, and the inner layer where there is no yolk. In young yolkless ova, whether in sections from immature ovaries in which all the ova are in this condition, or in sections from ovaries in which the majority of ova are larger and developing yolk, the whole of the protoplasm is deeply stained, almost as deeply as the nucleoli, while the rest of the germinal vesicle is scarcely stained at all. In fact, the protoplasm of the ovum from its earliest appearance is distinguished by its affinity for stains, which causes young ova to contrast vividly with the connective tissue of the sections. The staining is less after the action of chromic acid, but after corrosive sublimate or picro-sulphuric acid it is usually intense. Yolk substance, on the other hand, does not stain at all, and hence in older eggs the contrast between the unstained yolk layer and the inner protoplasmic layer is marked. In the older eggs, however, the inner unyolked protoplasm does not stain so intensely as the protoplasm of the young unyolked eggs. In some preparations the protoplasm of the unyolked ova is much vacuolated; this occurs only when some preserving agent containing much nitric acid has been used, such as Perenyi's mixture or picro-nitric acid, and is due to the action of the nitric acid.

Several investigators have expressed the conclusion that the vitelline nucleus is connected with the formation of the yolk,—is the centre, in fact, at which this process takes place. This is a suggestion which one would be glad to accept if possible, because it would afford a satisfactory explanation of the presence of this body, otherwise so difficult to understand. A very interesting and useful examination of the problem from this point of view is contained in the account given by Professor Emery of the history of the egg of Fierasfer in his monograph on that genus published by the Zoological Station of Naples. In many respects I find Professor Emery's observations and views much more in agreement with my own than those of other authors who have considered the development of the egg in fishes. In my judgment he shows a sounder and more comprehensive grasp of the succession of appearances to be interpreted, and has no inclination, like many others, to form extraordinary conclusions inconsistent with the general view of the nature of the egg, and supported by scarcely any evidence.

Emery's description of the earlier history of the vitelline nucleus agrees, to a great extent, with mine. It appears, he says, as a small mass of granulations excentrically situated, and then becomes larger and denser, but never acquires a definite boundary. Its ultimate history consists in its gradual disintegration with the formation of the vitelline spherules. The granular vitelline nucleus assumes an irregular form, more or less stellate, and often shows in its interior one or two small clear vacuoles. Around the nucleus extends an obscure zone, semilunar in section, of very minute granules, the beginning of the formation of the vitelline globules. This zone continually extends and surrounds the whole ovum, and as the yolk-globules get larger the vitelline nucleus becomes merely a small clear space in the layer of formed yolk. Emery goes on to say that it is not clear from these facts whether the yolk-globules are formed exclusively at the expense of the vitelline nucleus, or in part from this and in part directly from the plasma of the ovum, or if, lastly, the vitelline nucleus is formed and disappears without its substance contributing to the production of the yolk.

Emery, then, was not able to decide in what way the vitelline nucleus is connected with the formation of the yolk-globules, but he states that the development of these globules commences in Fierasfer in the immediate neighbourhood of the nucleus and extends outwards. It should be noted that the eggs of Fierasfer are, when mature, transparent and pelagic like these I have studied. I have been unable to find any indication that the yolk commences first in the neighbourhood of the vitelline nucleus. As I have already stated, the yolk layer is at first wholly external to the nucleus, and there are no yolk-globules or granules at the side of the latter. When the formation of granules begins it appears as a thin layer round the whole of the outside of the plasm of the egg, and is not thicker near the vitelline nucleus than elsewhere. In most ova the layer of yolk in sections is of uniform thickness, but occasionally it is thicker on one side than the other, and then the vitelline nucleus is not at the thickest part. In spite of the fact that the largest yolk-globules are those of the inner part of the yolk layer, it seems certain that the increase of yolk takes place by the new formation of globules added to the layer on the inner side. Forming globules are seen at the inner edge of the layer. After the yolk layer has so increased that its inner border is internal to the vitelline nucleus, it is clear that the new formation of globules can have nothing to do with that body.

The most recent published paper on the yolk nucleus is that by Jesse W. Hubbard, of Indiana University, U.S.A.* This investigator studied the eggs of *Cymatogaster aggregatus*, a viviparous fish of the coast of California, and his conclusions closely agree with my own. Cymatogaster belongs to the family Embiotocidæ, which is allied to the wrasses. The eggs of Cymatogaster are small, ·3 mm. in diameter, and being developed within the ovary the quantity of yolk in them is naturally small. The preserving reagent used by Hubbard was Flemming's strong mixture, the effects of which I have found in my own experience to be destructive to many parts of the egg. Like myself, Hubbard could see no trace of the yolk nucleus in very young fish, in those under 4 cm. in length. It was present in the ovaries of specimens over 7 cm. The smallest egg in which the body was observed was ·02 mm. in diameter, and it appeared as a cap of stained protoplasm fitting round one side of the nucleus.

In a slightly larger egg the yolk nucleus is separate from the germinal vesicle, and it gradually moves away from the latter. Hubbard concludes that the yolk nucleus originates from the germinal vesicle not by division, but by a general extrusion of substance. It passes to the external region of the egg, and when the yolk is formed and the egg is ripe it is situated at the yolk pole of the egg, opposite the blastodisc. It remains visible in the same position in the yolk after the egg is laid, and during segmentation until the closing of the blastopore, when it breaks up and disappears. Hubbard considers that there is no direct evidence in support of the view that the yolk nucleus is the centre of yolk formation; he has seen no indication that it gives rise to yolk. When the yolk forms it is distributed uniformly about the centre of the egg. Perhaps Hubbard's most important result is that the yolk nucleus passes to the opposite pole of the egg to that occupied by the germinal vesicle, and so defines the yolk pole, or, as it is sometimes called, the vegetative pole, long before the germinal vesicle has passed to the surface of the egg from the central region. I have not yet examined the last stages of maturation of the eggs of flat fishes. I have never detected the yolk nucleus in the eggs of these fishes after fertilization, when, if it is to be seen at all, it would be found in the thin layer of protoplasm which encloses the continuous mass of yolk. In my sections of the ova of conger nearly ripe, taken from females which have died in our tanks with enlarged and much-developed ovaries, in which ova the yolk is fully developed, I have not been able to detect the yolk nucleus.

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* *The Yolk Nucleus in* Cymatogaster aggregatus, Proc. Amer. Philos. Soc., vol. xxxiii, 1894.

The wrinkling of the membrane of the germinal vesicle already mentioned is an indication of its degeneration. In the later stages of maturation, as the limit of the yolk layer approaches the germinal vesicle, the membrane gradually disappears, and the nucleoli become scattered in the reticulum of the vesicle. At the same time this reticulum appears to become denser, and although it still remains unstained it has a more solid continuous appearance. In eggs nearly ripe—for instance, in preparations from a plaice killed in January, in which some of the eggs were becoming transparent—the whole body of the ovum is crowded with large yolk spheres, and the germinal vesicle forms an unstained round island in the midst of these, containing a number of stained nucleoli. No membrane, separating the nucleus from the protoplasm in which the yolk spheres are contained, can be seen. The later changes by which the nucleus of the egg, and especially its nucleoli, pass from a central to an external position in the ripe egg when extruded I have not yet studied.

The description given shows the history of the ovum in a flat-fish from the time of its first origin in the germinal epithelium to the stage in which it is almost ready for extrusion. The history is probably almost exactly similar in all fishes which produce pelagic eggs and have an annual spawning season. As I pointed out in my previous paper, the great majority of the eggs pass through the whole of this history in the course of a year, between one spawning season and the next. I have made preparations from ovaries in which spawning had just taken place, spent ovaries, with the following results.

In my previous paper I described the condition of the spent ovary of the plaice, as seen when microscopically examined in the fresh condition, and expressed the conclusion that all the unripe eggs containing yolk remaining in the ovary were destined to degenerate and be absorbed. The chief characteristic of sections of a spent ovary consists in the number of empty follicles seen. These are the collapsed receptacles in which the ripe ova were developed, and from which they have been expelled. The mode of expulsion is constant and of some importance. The follicle bursts at the surface of the germinal tissue, the egg therefore escaping through a rupture of the so-called germinal epithelium. When this takes place the wall of the follicle becomes continuous with the external covering of the germinal tissue,—that is to say, with the germinal epithelium and the connective tissue which supports it. Such an empty follicle corresponds with what is called a corpus luteum in the mammalian ovary. In the fish its walls are thick, and contain many blood-vessels: it may be regarded as an elastic membrane, which, having been stretched round the large ripe egg, becomes thickened and contracted when the latter escapes. In the cavity of the follicle are always seen the separated and broken follicular cells, but there are indications of cells on the surface of the interior of the follicle, so that perhaps not the whole of the follicular epithelium perishes. The appearance of the empty follicles, opening by an aperture at the surface of the germinal tissue, and of their walls, continuous with the membrane at the surface, strongly suggests the idea that a follicle is simply a pocket formed in the germinal membrane and temporarily constricted off from it, being restored to it again when the mature egg is expelled. But whether the wall of the follicle becomes again a part of the germinal membrane and begins again to produce new ova, or whether it is gradually absorbed, is a question I am unable to answer at present. In the larger of the young yolkless ova in the spent ovary the vitelline nucleus is present.

I have now to describe some observations on ovaries in which the history of the ova presents considerable differences from that which is characteristic of flat fishes and other fishes with pelagic ova.

Henneguy,* in a recent paper on the vitelline nucleus, states that among all the Teleosteans whose ova he examined, those of the pipe-fish (*Syngnathus acus*) gave him the most interesting facts. These facts are described thus:—There are four stages of the development of the vitelline body: (1) The smallest ova have no vitelline body; (2) in ova more advanced than the youngest the germinal vesicle has a number of nucleoli round its circumference within the membrane, and a granular mass in the centre; the protoplasm of the ovum contains a round refringent body deeply stained in safranin, the vitelline nucleus; (3) in ova about ·06 mm. in diameter the vitelline nucleus has become elliptical in shape, and at its outer border is a larger rounded mass formed of a homogeneous substance full of granulations; (4) the whole is transformed into a mass of granules, such as that observed in the ova of the majority of Teleosteans. The outer rounded body is described as formed by a modification of part of the refringent body, by a process of disintegration which finally invades the whole of the latter, and transforms it into a mass of granules. Unfortunately Henneguy omits to state what is the condition of the yolk corresponding to these stages, and the only indication of the size of the eggs is that in stage 3 they are ·06 mm. in diameter.

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* *Le corps vitellin de Balbiani dans l'œuf des Vertébrés,* Journ. de l'Anat. et de la Physiol., No. 1, 1893.

My observations do not completely agree with Henneguy's, but before pointing out the differences I wish to say something of the ovary. This organ in the pipe-fish is an elongated narrow cylindrical tube. There is one on each side of the body. It has a salmon-pink colour, due to the colour of the yolk in the eggs. The inner lining of the tube, the germinal tissue, only projects into the cavity of the tube in one fold or lamina, which is longitudinal. In this lamina alone are the young eggs formed, and they are pushed away from it as they become larger.

A long series of stages of the developing ova can thus be studied in a single ovary, and the production of new ova seems to go on nearly all the year round,—at least, I have not yet seen evidence of a limited spawning season, and specimens with ripe ova or just spent have been opened by me from June to October. I believe that several batches of ova are produced in one season in succession. The number of ova produced is small, and, as is well known, they are received by the male into a skin pouch, and there hatched.

It is not difficult to open the ovary and examine the proliferating lamina on a slide. In the fresh state the young yolkless ova are not very transparent, and it is impossible to make out any other structure than the germinal vesicle. But on the addition of dilute acetic acid the protoplasm of the eggs begins to coagulate, and in it there appears in most cases (Fig. 2) a single oval body, which in the smaller ova is in contact with the membrane of the germinal vesicle, in the larger is between it and the exterior of the egg. This body is of considerable size, both it and the nucleoli in the germinal vesicle being relatively larger than in the egg of the flat-fish. Another peculiarity of this vitelline body is that it has a most distinct and definite outline, and a refringent homogeneous interior. Occasionally a few granulations appear in its centre. The body is not much unlike a nucleolus, but the nucleoli, under the action of acetic acid, show internal vesicles and the vitelline body does not; the latter has also a pale yellowish colour, while the nucleoli are colourless.

FIG. 2.

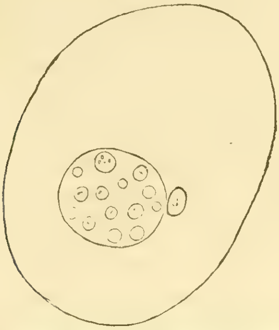

FIG. 3.

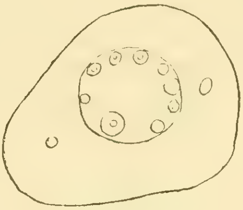

FIG. 2.—Egg in the germinal ridge of *Syngnathus acus* examined fresh with addition of 1 per cent. acetic acid. Shows the vitelline body close to the germinal vesicle.
FIG. 3.—Another egg in the same preparation, showing two vitelline bodies on opposite sides of the germinal vesicle.

The most remarkable fact about the vitelline nucleus in the ova of the pipe-fish is that there are often more than one of them in a single egg, frequently two, and I have seen as many as four. In the latter case the four were in a cluster, as though produced by the division of one, but when there are two they may be both on one side of the germinal vesicle, or one on one side and one on the other (Fig. 3). Henneguy examined the ovary of the pipe-fish apparently only in sections, and would not be so likely in that case to recognise the presence of two vitelline bodies in one ovum. The bodies can be well seen and studied in preparations of portions of the germinal lamella mounted whole. My best preparation of this kind was fixed in a mixture of chromic, osmic, and acetic acid, and stained with hæmatoxylin. The presence of two vitelline bodies in some ova in this preparation is easily confirmed. It should be noted that when two are present they are smaller in size than when there is only one. The structure certainly persists unchanged in ova in which yolk has begun to form. I have been able to distinguish it clearly in such ova of a diameter up to ·29 mm., and in these it is unchanged, showing no signs of the conversion into a granular mass which Henneguy describes as commenced in ova only ·06 mm. in diameter. The vitelline nucleus is entirely unstained and homogeneous, and has an appearance very different from that of the nucleoli, which are somewhat shrunken, and are stained. In ova larger than ·3 mm. I am unable to distinguish the vitelline nucleus in the yolk. The latter forms in the eggs of Syngnathus in a manner different from that described in the plaice. It does not form a definite external layer gradually thickening towards the centre of the ovum, but appears uniformly throughout the protoplasm in small, not very distinct or refringent granules, which increase in number and size. In the larger ova the yolk appears as large rounded spheres in the meshes of a protoplasmic network.

To turn now to the examination of these ova by means of sections. I have found it very difficult to preserve the ova satisfactorily for cutting. The vitelline nucleus is usually preserved, but either the germinal vesicle or the protoplasm or both are more or less destroyed by the preserving reagents. I have found in this case, as with the ovaries of flat fishes, that the much-vaunted mixtures of Flemming—namely, chromic, osmic, and acetic—are not satisfactory, and that the fault lies in the acetic acid, which causes shrinking of the nucleus and destruction of its delicate reticulum. Chromic and osmic alone, when the chromic is not too strong, have a good effect, but have the disadvantages of contracting the nucleoli, preventing staining, and making the yolk hard and brittle. Corrosive sublimate, either alone or with acetic acid, produces quite disappointing results on the ovaries of pipe-fishes.

In none of my sections have I seen the modifications of the vitelline nucleus described by Henneguy, although I have used the preserving reagents and stains which he employed, namely, Flemming's mixture and safranin or hæmatoxylin. I have also used the triple stain safranin, gentian violet, and orange G. After some modes of treatment the vitelline nucleus is stained, but never granular. The largest egg in which I have seen the body is ·36 mm. in diameter, and in this it is as definite in outline and as simple in structure as in the small unyolked ova. I have seen no indication of modifications tending to the breaking up or disappearance of the nucleus; in the larger eggs I can find no trace of it. As to its earlier history, it is seen in eggs ·06 mm. in diameter in direct contact with the exterior of the germinal vesicle. In one egg there are two of these bodies at different parts of the membrane of the vesicle, one smaller than the other. In smaller eggs I have seen no trace of it. These smaller eggs form a cluster or nest at the very apex of the germinal lamella. As to their origin, I have not been able to get sections which show them as perfectly as I should wish, but I have seen primordial ova in the epithelium covering the apex of the lamella, and that is the source from which they all spring.

III. A PIEBALD PLAICE.

In the memoir by Dr. MacMunn and myself on the *Coloration of Fishes* (Phil. Trans., 1894) specimens of flat fishes are described in which some portion of the upper side is abnormally destitute of pigment. Thus abnormalities consisting in the pigmentation of part or whole of the lower side are balanced by abnormalities consisting in the absence of pigment from areas on the upper side. I have recently received a living specimen of the plaice exhibiting the latter kind of abnormality. It was caught in the Hamoaze, and brought to the Laboratory on October 3rd. It is still living in one of the tanks. The anterior third and the caudal third of the upper or right side in this specimen are pigmented as in a normal plaice, the red spots having the usual appearance and position; but the middle third is white like the whole of the lower side. The white unpigmented area is bounded by two definite irregular lines, the anterior passing transversely across the body just behind the pectoral fin, the other in the posterior region of the body. There is an isolated round patch of normal pigment within the white area dorsally.

Mr. Holt, in the previous number of this Journal (p. 188, *et seq.*), gives reasons why my rejection of atavism as an explanation of the abnormal coloration of the lower side cannot be held to be valid. But I can see no reason why the principle which explains the occurrence of pigment on the lower side should not also explain its occasional absence on the upper. If it is atavism in the one case it is atavism in the other, and the occurrence of piebald plaice, or flat fishes white on both sides, is as good an indication that this family of fishes is descended from ancestors that were unpigmented on both sides, as the occasional presence of pigment on the lower side that they are descended from ancestors coloured on both sides. Thus it is obvious that atavism fails to explain both kinds of abnormality, whereas the explanation adopted by Mr. Bateson and myself applies equally well to either case. That explanation is that in certain cases one side, instead of developing normally, partially or completely imitates the other. It does not require much consideration to see that Mr. Holt's reference to what he terms ambi-ciliation, tends to support my views, and not his own. For it is difficult to connect the varying conditions of the dermal armature in different kinds of flat fishes with an original ancestral condition. If the ciliated scales of the brill are ancestral, then the tubercles of the turbot are new, and *vice versâ;* but when the lower side is pigmented, it is also provided with scales or tubercles like the upper, thus proving that the lower side has in the abnormal specimen formed itself after the pattern of the upper side, and not after the pattern of a remote ancestor. It has never been maintained, as Mr. Holt suggests, that this unusual development of dermal armature on pigmented lower sides has anything to do with the action of light; on the contrary, I have always maintained that abnormalities of coloration occurring in nature are independent of the action of light on the individual.

The subject is too complicated to be discussed at any length here, belonging as it does to the intricate problems of ontogeny. But one interesting consideration may be mentioned. In a piebald plaice, such as the specimen here recorded, the unpigmented area is exposed to light as much as the rest of the upper side, and yet it remains unpigmented. How then, it may be asked, can it be maintained that pigment is developed on the lower side of a normal specimen by exposing that side to the light? Some may be inclined to believe that the two things are incompatible, and that therefore the pigment which appeared in my experiments is due to some factor other than the action of light. But it seems to me that, as far as the experiments are concerned, all other factors were excluded; and the explanation in the other case seems to be as follows:—I have said that the white area on the upper side is an imitation of the lower side, and I think that there is probably some peculiar connection between this area and the lower side, so that it may be regarded, in a sense, as an extension of, and continuation of, the skin of the lower side. Therefore, so long as the lower side remains white, this area of the upper side will also remain white. Possibly, if the lower side became pigmented, this white area on the upper side would also become pigmented, and it would be a curious experiment to expose the lower side to the light, and see if both it and the white area on the upper side would develop pigment.

IV. GROWTH AND DISTRIBUTION OF YOUNG FOOD-FISHES.

In April, 1893, I had the pleasure of undertaking some experiments with young flounders for the late Dr. Romanes. I procured the specimens as usual from Mr. Dunn, of Mevagissey. They were the young of the year in process of metamorphosis, and among them I received five young soles a little more advanced in development. I placed these five soles in one of the table tanks in the Laboratory, a tank 5 feet long, 2½ feet wide, 1½ feet deep. When received these soles were about 1·5 cm. long, or nearly ⅝ inch.

During the following summer a number of young fish of different kinds were put into the same tank, and they have been fed and watched with some care ever since. The following is an account of their growth and history.

In June a few young turbot and brill in the pelagic transformation stage were put into the tank.

On July 5th a plaice 6·9 cm. ($2\frac{3}{4}$ inches) was put in; it was taken in Cawsand Bay.

On July 21st a turbot 3·5 inches long was put in, taken at the surface in the Sound.

On July 28th I put in six plaice, 6·5 to 8·5 cm. ($2\frac{1}{2}$ to $3\frac{3}{8}$ inches). These plaice were judged to be of the brood of the year, *i. e.* hatched the preceding January, February, or March.

On September 2nd I took out one of the soles which was dead; it was 9·6 cm. long, or $3\frac{3}{4}$ inches, and must have been not much more or less than six months old.

On October 19th I emptied the tank and measured all the fish in it. The inventory was as follows:

7 plaice: 7 cm. ($2\frac{3}{4}$ inches), 12·3 cm., 12·8 cm., 13·0 c.m., 14·1 c.m., 14·4 cm., 14·8 cm. ($5\frac{3}{4}$ inches). 1 sole, 9·9 cm. long. 3 brill: 8·0 cm., 8·5 cm., and 10·4 cm. 3 turbot: 6·5 cm., 9·5 cm., 9·9 cm.

There were also three pollack, about 12·3 cm. long, one red mullet and one bream, all young fish of the year.

On April 4th, 1894, several of the fish died, in consequence of a temporary stoppage of the circulation. They were 1 turbot, 10·8 cm. long ($4\frac{1}{4}$ inches.); 1 brill, 11·3 cm. long ($4\frac{1}{2}$ inches); 1 plaice, 16·7 cm. long ($6\frac{3}{4}$ inches).

I have not been able to give sufficient attention to this tank during the past summer to record the size of each specimen that died in it. I examined all the fish in it on December 31st, 1894, and found only the following remaining:—1 sole 14·7 cm. long ($5\frac{3}{4}$ inches); 1 plaice 21 cm. long ($8\frac{1}{4}$ inches); 1 plaice 18·5 cm. long ($7\frac{1}{4}$ inches).

This experiment is obviously a very small contribution to the study of the growth of fishes. Plaice, sole, turbot, and brill evidently do not bear confinement so well as flounders, and it would be better to have a larger number of specimens in a larger tank. Nevertheless the results show observed sizes at known ages, and there can be no doubt that some fish in the sea grow no faster or slower than those. It is shown that a sole may reach from $3\frac{3}{4}$ to 4 inches when six months old, and may not exceed $5\frac{3}{4}$ inches when about twenty months old. It is clear, therefore, that soles not differing much from 4 inches in length in spring are probably a year old. This year I had an opportunity of examining a large number of soles of about this size.

In the course of some work on which I was engaged for the Essex Technical Instruction Committee I made as careful a study as possible in May and June, 1894, of the fish and marine fauna of the estuary of the Colne and the neighbouring sea channel called the Wallett. On June 8th I went out for a trip in one of the shrimping smacks belonging to Brightlingsea. The boat was 35 to 40 feet long, cutter-rigged and very low in the water. She carried a shrimp trawl of 25 feet beam, with a mesh at the cod end of about $\frac{1}{2}$ inch square. We ran down the Colne with a fair breeze and shot the trawl just beyond the bar, towing eastward, and afterwards took two other hauls further eastward and further from the shore, the last being finished when we were a little to the east of Clacton.

In each haul there were a large number of interesting things besides the shrimps which were the object of the fishing. The red shrimp (*Pandalus annulicornis*) was most abundant, but there were some brown (*Crangon vulgaris*) also. The ground at the second haul was hard cultch; the dredge put over for a few minutes brought up only empty oyster-shells. The depth was 2 to 5 fathoms at low water.

A few fair-sized fish were caught, but none mature. They were plaice, small soles, and dabs. A great number of very small fish were caught. The smallest were dabs and plaice, the latter from 2 to 6 inches long. The most noticeable feature was the very large number of lemon soles 4 or 5 inches long, and doubtless a year old; hundreds of these were culled out from the first haul, and they were almost as numerous in the second and third. Soles of the same range of size, 3 to 5 inches, were also very abundant, but not quite so numerous as the lemon soles. I have never met with so large a collection of yearling soles and lemon soles. I was unable to give my attention to a thorough investigation of this ground to find out what the fish were feeding on, and what their prey was feeding on,—in fact, to obtain an explanation of the abundant life in this channel. I opened a young dab 4 inches long, and found it contained a small Amphipod, probably Gammarus. I found a *Gadus luscus* had its stomach distended with the red shrimp Pandalus.

V. Notes on Rare or Interesting Specimens.

During last August mackerel were unusually plentiful in Plymouth Sound, and several large hauls of them were made by means of seines close to the shore below the Laboratory, in the little cove known as Tinside. The Laboratory fisherman, watching the hauling of a seine in Barnpool, saw eight shad caught with the mackerel, and these, together with some of the "britt" which escaped from the net, he secured and brought to the Laboratory. I made a careful examination of these fish, and found that they belonged to the species *Clupea alosa,* having the slender numerous gill-rakers of that species. But in most of the specimens there was a row of dark spots on the side behind the shoulder-spot. Such spots are constant in the other species, *C. finta,* but, according to Day, have been recorded especially in the young of *C. alosa.* My notes on the specimens are as follows:

(1) Male: 14½ inches long; single row of nine rather large spots. Gill-rakers in first arch about 107, seventy on the horizontal portion.

(2) Male: length 13¾ inches; gill-rakers on horizontal portion of first arch, seventy. Nine spots on side in single row.

(3) Male: 13¼ inches; spots in single row, not very distinct; counted six behind the shoulder-spot.

(4) Female: 13½ inches; double row of spots on each side, counted twenty-one altogether; spots of one row opposite spaces of the other.

(5) Female: a double row of spots; nine in the upper row, two in lower.

(6) Female: counted seven spots.

(7) Female: five spots.

(8) Female: no spots.

In some cases the spots were symmetrical on the two sides, but in others they were scarcely to be distinguished on one side of the body, although well marked on the other.

In the stomach of one specimen were three half-digested britt, doubtless from the shoals, some of which were taken by the seine and brought up with the shad. These were young sprats, and it was for the sake of feeding on these that both the shad and mackerel were in the Sound.

The weight of the largest shad was 1 lb. 1½ oz.; of the smallest, 9½ oz. As far as I could judge the specimens had previously spawned: the breeding season is stated to be May and June, and it probably spawns in the Tamar.

On September 8th four more specimens of the same species were brought up, taken in a seine on the west side of the Hamoaze.

Auxis Rochei, Günther.—A specimen of this species was obtained on August 13, having been taken with mackerel in a seine at Mount Batten. It was 16 inches long, sex female. The stomach was empty, the ovaries small. Under the microscope the eggs were found to be small, transparent, and yolkless; probably the fish had recently spawned. Specimens are stated by Day to have been taken occasionally on the east coast and the south coast of Britain, but not very frequently. He mentions the record of one taken at Looe in 1843, of two in Mount's Bay in 1844, and of one at a later date at Mevagissey by Mr. Dunn. This fish resembles the mackerel in many respects, the chief difference being that the scales are confined to a distinctly limited region behind the head, forming what is called a "corselet."

Orcynus thynnus, Lütken, *Thynnus thynnus*, Günther.—A specimen of the common tunny 3 feet long was brought to the Laboratory on September 19th. It was caught in mackerel drift-nets some miles from Plymouth Sound, only 18 mackerel being caught in the same haul. It was 3 feet long, and female. The ovaries were small, in an inactive condition, spawning having probably recently occurred. The eggs were very young. Dr. Bassett Smith examined the specimen for parasites, and found *Brachilla thynni* behind the pectoral fins, and a large number of Trematodes on the gills. The capture of a specimen of this species is not an unusual occurrence off the south-west coast in summer and autumn.

Myliobatis aquila, Cuvier.—A single specimen of this species was brought to the Laboratory on November 1st, probably taken by a trawler, but the exact locality of its capture was not ascertained. It measured 62·5 cm. (2 feet 1 inch) across the pectorals, 40 cm. (1 foot 4 inches) from the snout to the end of the conjoined pelvic fins, and 65·5 cm. (2 feet 2 inches) was the length of the tail.

I examined the viscera. The left lobe of the liver was of great size and thickness, and covered the whole abdominal cavity ventrally, the right lobe was much smaller, and dorsal to the left. The stomach, intestine, spleen, and pancreas were as in other Elasmobranchs. The contents of the stomach were much digested, but showed remains of molluscs: an operculate foot, apparently of Buccinum, a proboscis of the same, and some pieces of Pecten shell were recognised. The absence of claspers indicated that the specimen was female. The ovaries were smooth, extending nearly the whole length of the body cavity, broad and flat, and joined at their bases across the middle line. The eggs in process of maturation were visible, the specimen being apparently immature. The anterior ends of the oviducts with their openings were very distinct along the sides of the root of the liver just behind the pericardium, but the rest of the tubes were concealed beneath the pericardium. The posterior ends were dilated, and lay over the large kidney (metanephros). There was no distinct egg-shell gland. The species and the other members of the family are generally stated to be viviparous, and Couch's account of the purse which he attributed to *Myliobatis* is too vague and defective to be regarded as important evidence. Members of the allied family Trygonidæ have been recently shown not only to be viviparous, but to nourish their young in the uterus by means of long glandular papillæ of the wall of the uterus, which pass through the spiracles into the stomach of the fœtus.

In my specimen of Myliobatis the abdominal pores were distinct and open behind the aperture of the cloaca.

The Larva of the Eel.

By

J. T. Cunningham, M.A.

Le Leptocefalide e la loro trasformazione in Murenide. Nota preliminare del Corr. G. B. Grassi e del dott S. Calandruccio. Atti d. R. Accad. d. Lincei, Ser. v, vol. i.

Soluzione di un enigma antichissimo ossia. Scoperta della metamorfosi dell' anguilla. Grassi e Calandruccio. Neptunia, 15—30 Sett., 1894.

From the time of Aristotle many naturalists have desired, and a large number have attempted, to discover something about the breeding and development of the common eel, but until the present time it has remained a baffling mystery. At last the mystery is to a great extent penetrated; the larva of the eel has been discovered, and turns out to be a creature which was known before. Until the present year absolutely nothing was known of the history of the eel between the disappearance of the parents in the sea in autumn, and the appearance of the young transparent elvers in early spring. Professor Grassi and Dr. Calandruccio have now discovered that one of the larval forms called Leptocephali is the larva of the common eel. This form was described and distinguished as *Leptocephalus brevirostris,* but it was not suspected that it belonged to the eel.

In my paper on the *Reproduction and Development of the Conger,* in No. 1, vol. ii, of this Journal, 1891, I gave some account of what was known at that time concerning the habits and history of the Leptocephali. I mentioned there that only one kind of Leptocephalus was known on the British coasts, namely, L. Morrisii, and that the transformation of a specimen of that kind into the conger had been observed at Roscoff, by M. Yves Delage. Leptocephali are most frequently captured at Messina, and it was largely from specimens obtained there that a number of different kinds were defined and described. In 1856 the Catalogue of Apodal Fish, drawn up by Professor Kaup, of Darmstadt, was published by the trustees of the British Museum. Its object was to give a description of all the genera and species of apodal fish, *i. e.* fish destitute of pelvic fins, existing in the various English and Continental collections. In this work the family Leptocephalidæ was defined as comprising small, compressed, transparent fish, entirely devoid of scales, and having a very imperfect cartilaginous skeleton. The forms were distinguished into four genera,—Esunculus, Hyoprorus, Tilurus, and Leptocephalus. It must be remembered that in this work of Kaup's, as in much work of a similar kind, the method is purely empirical; specimens are described simply as they appear, and different forms are called different species without any consideration of the relations they may bear to each other, without regard to such questions as : are the specimens adult or larval ? or : may not many of the different forms be the same animal at different ages or in different sexes ? But even from the empirical descriptive point of view the inclusion of Esunculus in the Leptocephalidæ, or even among the apodal fishes at all, was a mistake, for it has distinct pelvic fins, and Kaup gives the number of fin-rays in these as five. It has short dorsal and ventral fins, nearly opposite to each other, and a forked caudal fin. It is obviously the larva of some fish belonging to a family other than the Muræenidæ. It resembles somewhat a young Clupeoid, but not very closely ; the head is smaller, the dorsal fin farther behind the pelvic. There were a large number of specimens of this form in the Paris Museum, but the place of their capture is not recorded.

Hyoprorus is a genus of which only one species was known, *H. Messinensis*, discovered by Gegenbaur at Messina, originally described by Kölliker. Kaup describes a single specimen, obtained like the others from Messina. The specimen was 4·96 inches long, and had a muræenoid continuous median fin extending round the body posteriorly, the extremity of the tail being pointed. The peculiarity of the genus is the sudden broadening of the body in the vertical plane immediately behind the head. The jaws are elongated and straight, with mere traces of teeth. Mr. Gill in his paper on the relations of the Leptocephalids in 1864 expressed the conclusion that Hyoprorus was the young stage of *Nettastoma melanurum*, a Mediterranean species of marine eel with a long and depressed snout, no pectoral fins, open gill apertures, and a tail twice as long as the body, tapering to a point. Dr. Günther in 1870 expressed his entire concurrence with this view.

Tilurus, of which two species were described by Kaup, is a much-elongated transparent compressed fish, also found at Messina. One specimen was 12·21 inches in length. The anus is situated near the end of the attenuated tail, which is as thin as a hair and coiled at its extremity. Dr. Günther was unable to refer Tilurus to any known fish, and thinks it does not belong to the Muræenidæ.

Of Leptocephalus Kaup distinguished the following species :

Morrisii.—A blunt head, scarcely visible teeth ; lateral line, belly, and anal fin dotted with black points; tail pointed; greatest height one ninth of the total length.

Spalanzani.—Blunt head, almost imperceptible teeth; body narrower in proportion to length.

punctatus.—A round vermiform body; points along the lateral line, oblique pairs of dots along the edge of the belly; anus before the middle of the body, and a row of indistinct points on the anal fin. Specimen came from Messina.

diaphanus.—Anus nearly in the middle of the total length, dorsal fin commencing somewhat before the anus; 4·37 inches long. Also from Messina.

Kölliker.—A blunt caudal fin with distinct rather long rays; body not higher vertically than the head. Also from Messina.

Gegenbauri.—Has a similar tail, but the height of the body is greater. Also from Messina.

Bibroni.—Similar to the last, but anus behind the middle of the body. From Messina.

Yarrellii.—Similar, but anus still further back. From Messina.

stenops.—Stout teeth and large eyes closely approximated to one another. Probably from Messina.

longirostris.—Has long jaws and distinct teeth, and the body broadening suddenly in the vertical plane behind the head. From Messina.

tænia.—A round head, large projecting globular eyes, short snout, much-elongated broad body. Specimens from India and the Maldives.

brevirostris.—No dots; fourteen teeth in each jaw; small slender tail sustained by visible rays; eyes black; total length 3·15 inches. Locality Messina.

He also distinguished *acuticaudatus, Dussumieri, dentex, marginatus, lineo-punctatus,* and *capensis.* In a later paper, published in 1860, Kaup identified *L. Spalanzani,* Risso, with *Morrisii,* and described two other species of Leptocephalus under the names *Haeckeli* and *Kefersteini.*

Kefersteini.—Seven roundish spots composed of points along the intestine; anus a little behind the middle of the body; head extremely small, with very fine teeth. From Messina.

Haeckeli.—Head small and pointed, tail only one eighth the length of the body. Resembles *brevirostris,* but the snout is longer, the body not so high, and the tail less pointed. From Messina.

In my former paper I referred to the remarks concerning Leptocephalidæ contained in Dr. Günther's Catalogue, vol. viii, p. 138. It is there suggested that Myrus, Ophichthys, and perhaps also Muræna have their Leptocephaline forms. Pointing out that the question whether the Leptocephali were normal or abnormal larvæ could only be decided by investigation of living specimens, Dr. Günther abandons the practice of distinguishing different species among them, and merely groups together the known forms which appear to have a common origin, or which by their general similarity appear to be closely connected together. Thus he groups together *L. Morrisii, diaphanus, Bibroni, Gegenbauri, Köllikeri,* and *punctatus.* We shall see that in recognising *punctatus* as the more developed stage of *Morrisii,* Günther is proved by the researches of Grassi and Calandruccio to have been right, while many of the other forms grouped with *Morrisii* by Günther turn out to be the larvæ of adult forms closely allied to the conger.

It is a curious fact that Leptocephali which are rarely observed or captured in other places are not uncommon at Messina. Commenting on this fact in 1883, Bellotti, an Italian naturalist, maintained that it gave support to the view that these creatures were not normal larvæ, but abnormal overgrown individuals whose proper development had been arrested by exceptional conditions. This investigator had only been able to capture a few rare specimens at Genoa, Nice, and Naples, and none at all at Palermo, Catania, or Siracusa, which are near Messina. He surmised that the impetuous currents and the numerous whirlpools of the narrow Straits of Messina were the exceptional conditions which caused the larvæ of congers, &c., to pass through an abnormal course of development. Until the normal development was known, arguments of this kind, as I have remarked in my previous paper, were of little importance.

Signore Grassi is an Italian naturalist who lives at Catania. He is one of those who devote themselves chiefly to the application of rigid scientific method to investigation in the department which used to be called natural history, and which it has been proposed to distinguish by the term bionomics. He has made himself famous recently by his marvellous discoveries concerning the life histories of the termites or white ants. In 1892 he published a brief account of some researches which he and Dr. Calandruccio had made on the Leptocephali. For five years they had noticed that these forms were common enough at Catania, being captured at all times of the year and sometimes in abundance. They were most plentiful in the harbour, and were caught by the nets called tartarene and sciabica, nets which are dragged over a sandy or muddy bottom. In these authors' opinion this abundance of Leptocephali at Catania is peculiar to the period mentioned, and to be attributed to the volcanic eruptions which have sent much lava into the sea, and so compelled certain Murænidæ to leave their usual haunts among the rocks or at great depths and seek shallower water. It is obvious that this suggestion has no great air of probability.

The careful experimental investigation of the Leptocephali was carried on by these naturalists in the year 1891–2, and the following were the results. In the development of the conger (*Conger vulgaris*) three stages can be distinguished :—First, a tænioid form resembling *L. Morrisii,* except that the dots on the lateral line are limited to the posterior extremity of the body; second, *L. Morrisii* itself; and third, the form which had been previously distinguished as *L. punctatus:* from this the perfect conger is directly developed. The first tænioid form has long and fine larval teeth; these are wanting in *Morrisii,* in which the permanent teeth begin to develop in a position internal to that of the larval.

During the metamorphosis there takes place a gradual reabsorption of the gelatinous skeleton, much pigment develops, the anus passes into a more anterior position, and so much diminution in size takes place that from larvæ 12½ cm. long (5 inches) are obtained congers only 7½ cm. (3 inches). During the transformation, which may not take more than a month, the Leptocephali take no food or only minute particles. The transformation may be followed without any difficulty in specimens kept in any aquarium, or even in tubs; the authors observed it in 150 individuals. This is surely a sufficient confirmation of the isolated observation of Delage. All the various stages observed in captive specimens were also seen in specimens taken from the sea. In the aquaria the larvæ hid away in groups, threaded through the crevices under stones, the eggs of Aplysia, &c.; they also sought the darkest corners of the aquaria and avoided the light.

L. diaphanus of Kaup was found to develop into *Congromuræna balearica.* This is a Mediterranean species of Congromuræna, a genus very similar to Conger, but distinguished by the presence of large muciferous cavities in the front part of the skull, and the dorsal fin commencing at a more anterior point, namely, nearly above the gill opening. *L. Köllikeri* proved to be the larva of *Congromuræna mystax,* the only other Mediterranean species of the genus; and *L. Haeckeli, Yarrellii, Bibroni, Gegenbauri,* and probably *brevirostris* were found to be merely different stages in the development of the same form. The investigators have now come to a different conclusion concerning *brevirostris,* but with regard to the others reference to Kaup's original descriptions and figures shows that they resemble one another in the truncated, rather broad form of the tail and its distinct rays. In the course of development it appears that the post-anal or caudal portion of the body continually grows longer in proportion to the pre-anal or anterior portion. It thus appears that the Leptocephaline forms grouped with *Morrisii* by Günther are larval stages of Conger and Congromuræna, and his view of their close connection is shown to have been remarkably sound.

L. Kefersteini was found to be a somewhat rare form at Catania, but it was easily kept alive in aquaria, where it buried itself in the sand at the bottom and changed into *Ophichthys serpens*. Ophichthys is distinguished chiefly by having the extremity of the tail free, not surrounded by the median fin, and a pointed snout projecting beyond the lower jaw. *L. stenops* was found to be the larva of *Myrus vulgaris*, whose characters are—nostrils on or close to the margin of the upper lip, caudal rays very short, tail twice as long as the trunk, white lines across the occiput, and white pores on the face and lateral line. *L. longirostris* was similarly connected with Muræna, which has narrow gill openings, and a body suddenly becoming very thick just behind the head. This character is markedly exhibited by the larva. *L. tænia* is probably the larva of Sphagebranchus, which is allied to Ophichthys (united with it by Günther), but has the gill openings convergent on the ventral surface of the head.

The same naturalists, pursuing their researches on the Leptocephali, have now satisfied themselves that the species *L. brevirostris* is the larva of the common eel. They have not, it is true, been able to follow the entire transformation on one and the same specimen, but they have verified the most important changes in several individuals, and have compared all the organs in these stages and in the perfect form, and have traced a gradual transition from the structure and characters of *brevirostris* to the fresh-water eel. *L. brevirostris* (Fig. 1) is a comparatively small Leptocephalid, scarcely reaching the maximum length of 8 cm. ($3\frac{1}{4}$ inches), with a maximum vertical height of 1 cm. The reduction in length during the metamorphosis may be somewhat more or somewhat less in different individuals, but never exceeds 3 cm.; that is to say, a fully transformed young eel, which is still very transparent, may be as short as 5 cm. (2 inches), but not less, and it is very slender.

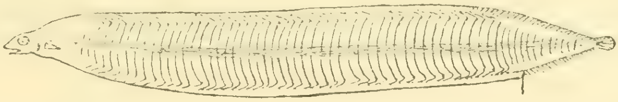

FIG. 1.—*Leptocephalus brevirostris,* after fig. 15, pl. xviii, of Kaup's Catalogue of Apodal Fish in the British Museum, 1856.

L. brevirostris has not hitherto been found anywhere else except in the Straits of Messina. Is it possible, ask the Sicilian naturalists, that eels undergo a metamorphosis only in that place, and elsewhere have a different history? The hypothesis is exceedingly improbable. They have made investigations, and convinced themselves that nowhere can young eels be obtained which are less than 5 cm. long. Contrary assertions are to be found in literature. It has been asserted that there are eels only 2 or 3 cm. long, or even as small as 7 mm. (about $\frac{5}{8}$ inch), but critical examination shows that no such statements rest on direct observation. The *Leptocephali brevirostres*, which are the larvæ of the eel, have hitherto escaped observation in other places on account of their habit of hiding themselves in the bottom of the sea.

The authors add some curious remarks concerning the history of the knowledge of the subject. They tell us that it is a fact that the fishermen of Augusta know by tradition the metamorphosis of the Muræinidæ, by which we presume is meant that they have a tradition that Leptocephali are the immature or larval forms of congers and eels. It is also a fact that at Catania the Leptocephali are commonly called *Morenelle*, or little Murænæ. It is to be inferred that from time to time some observant fishermen have noticed similarities or transition stages which led them to express this conclusion among their fellows.

Aristotle states, in his History of Animals, that eels have no sexes, nor eggs, nor semen, and that they arise from *γῆς ἔντερα*, the entrails of the earth. By this expression some have understood earthworms, others have maintained that the Greeks applied it to all sorts of creeping, limbless creatures living in soil or mud, and believed that these were spontaneously generated. At Palermo the Leptocephali are called *lombrici* or *vermicelli di mare*, and Grassi and his colleague suggest that perhaps the belief that these *lombrici* gave rise to Muraenids reached Aristotle in some form or other, and so caused him to write that eels arose from the entrails of the earth. The authors remark that if these suggestions are accepted we may well exclaim, "Nothing new under the sun." But probably most people will agree that, interesting as the traditional knowledge of the fishermen may be, as far as science in the present time is concerned, the knowledge of the transformation of the eel and other Murænidæ is due to the patient and fruitful investigations of Grassi and Calandruccio.

Considering that eels are so common, it will be a matter of much interest to make renewed attempts to discover their larvæ and those of the conger at Plymouth, and at other places outside the Mediterranean. The subject suggests two interesting questions : firstly, are Leptocephali pelagic or not, or are some pelagic and some not? secondly, are the eggs of the Murænidæ pelagic, or some pelagic and some not, as in other families of fishes? It appears from the account given by Grassi and Calandruccio that the Leptocephali at Catania are captured on the bottom, and we have just seen that these authors conclude that the larva of the eel has escaped capture in other places from its habit of hiding or burrowing in the sea bottom. In captivity the larva of the conger was found to hide at the bottom and avoid the light. *L. Kefersteini,* the larva of *Ophichthys serpens,* lived in the aquarium buried in the sand; and the larva of *Congromuræna balearica* also burrowed into the sand, although, singularly enough, it could only be kept alive on a naked marble bottom. We are not told whether these larvæ came out at night and swam about freely. That the larvæ of the conger and common eel are not constantly pelagic at night seems proved by the fact that they have never been taken in abundance in nocturnal tow-netting expeditions. I conclude, therefore, that these Leptocephali, and all those known from the Mediterranean, are not truly pelagic, but live on or in the sea bottom, and that the reason they are found in the open water or at the surface at Messina is that there the strong tidal currents and eddies stir up the bottom and carry their light bodies about as scraps of paper are lifted and borne along by the wind. Reference to my previous paper, and the records which are there cited, will show that in two cases *L. Morrisii* has been taken in a hand-net near the surface of the water, but in other cases it was taken from the bottom,—for instance, in the process of fishing for prawns. There can be little doubt that the larvæ of the conger and of the eel exist around our coasts in great abundance, under stones or buried in sand or gravel, and that we do not catch them because we do not know the right way to go about it.

But, on the other hand, we find constantly in narratives of oceanic zoological researches that Leptocephali were taken in abundance in ordinary tow-nets worked near the surface. This, it is to be remarked, occurs always in the tropics. For instance Giglioli and Issel, in their volume Pelagos, published in 1884, state that twice only during the voyage of the "Magenta" they found specimens of Leptocephalus in the pelagic net, once in sight of Java, once in the South Pacific.

In the "Challenger" narrative the occurrence of pelagic Leptocephali is only mentioned twice, once in the account of pelagic animals observed between Fernando Noronha and Bahia, off the coast of Brazil, 5° to 15° south latitude, the second time among those captured on the voyage from the New Hebrides to New York, in about the same latitude to the eastward of Australia in the Pacific. In the former case the Leptocephali were accompanied by the Pleuronectid larva of Rhomboidichthys, the larva originally known as Plagusia, characterised by the peculiarity that the lower eye reaches the upper surface by passing through the base of the dorsal fin. Dr. Günther gives the following account of the Leptocephali in his Report on the Pelagic Fishes of the "Challenger." He says that singularly few specimens were collected during the expedition, and these throw no new light on the question of origin. Six specimens obtained in mid-Atlantic belong to the form which has received the name *pellucidus* and other names. These other names are those associated by Grassi with *Congromuræna mystax*. One specimen obtained on the west coast of Africa at the surface belonged to the form *L. Morrisii*. Another, from a station near the Admiralty Islands, belonged to the form *L. tænia*. Lastly, a specimen from the North Atlantic had the characters of *L. brevirostris*. It is much to be regretted that no further description or any figures are given. If the comparisons are correct, it would follow that the larva of both the common conger and common eel were taken in the open Atlantic in a pelagic condition.

A. Agassiz remarks in Three Cruises of the "Blake," vol. i, p. 121, that we may trace the northern course of the Gulf Stream by the presence of Sargassum, Porpita, Leptocephali, &c., which are carried each year to the coast of Southern New England.

It seems evident that in tropical regions of the ocean truly pelagic Leptocephali are of constant occurrence and fairly abundant. It will probably be found that these are the larvæ of species of Muræenidæ other than those whose larvæ have been traced by the Sicilian naturalists. But in the present state of our knowledge it seems impossible to distinguish satisfactorily the oceanic pelagic forms from those of the Mediterranean, or from those which are not pelagic. Thus Grassi and Calandruccio suggest that *L. tænia* is the larva of species of Sphagebranchus, of which species occur both in the Mediterranean and the East Indies. But the names *tænia, marginatus, lineo-punctatus,* and *capensis* are grouped together by Günther as applying to much-elongated forms which appear to have been taken at the surface of the open ocean: some specimens reach a length of 25 cm., or nearly 10 inches. The specimens named *L. tænia* by Kaup came from India and the Maldive Islands, but we are not told whether they were pelagic; probably they were. If so, the question arises whether the form called *L. tænia* by the Sicilians is also truly pelagic, or if it belongs to a different species. It would scarcely be profitable to pursue these speculations further. What has been said is sufficient to suggest strongly that the characters and history of the Leptocephali still offer a most promising field of study and investigation, alike in the Mediterranean, in the tropics, and on our own coasts. It is much to be hoped that Drs. Grassi and Calandruccio will publish a complete account of their observations with satisfactory figures, in order to satisfy the interest and curiosity excited by their preliminary communications. It is worthy of remark that there is some similarity between the cases of the Leptocephali and the larval Pleuronectid originally described by Steenstrup as Plagusia, and probably belonging to the genus Rhomboidichthys. This larva is a conspicuous pelagic form in tropical seas on account of its large size, and in this respect and in its oceanic distribution differs from the smaller larvæ of other genera which are abundant on temperate shores, but whose pelagic life is but little prolonged. In like manner it will probably be found that the oceanic Leptocephali are peculiar to certain special genera among the Muræenidæ. In the article printed in Neptunia, the Sicilian ichthyologists make no mention of the well-known oceanic Leptocephali, and have overlooked their existence in formulating their general conclusion that these larvæ escape notice and capture by their habit of hiding at the bottom, except at Messina and Catania.

With regard to the pelagic condition of the ova of Muræenidæ, Grassi and Calandruccio state that they have been able from their own observations to confirm with complete certainty the suggestion of Raffaele that certain pelagic eggs described by him belong to this family. But they do not assert that they have identified particular eggs with particular species. If the eggs of the conger and common eel are really pelagic, it is an inexplicable fact that they have not been identified in the course of the careful and long-continued researches made on pelagic ova at Plymouth and other places on the Atlantic coasts of Europe.

North Sea Investigations.

By

Ernest W. L. Holt.

On the Destruction of Immature Fish in the North Sea.

I subjoin the results of statistical inquiries into this question, continued from the point at which they were left in the last number of this Journal. Having been permitted by the Council of the Association to undertake a series of lectures along the coast of Yorkshire on behalf of the North-eastern Sea Fisheries Committee during the present autumn and winter, I find it necessary to restrict the present paper to the smallest possible compass, reserving practically everything except the mere statement of figures until more time shall be available for the deduction of results.

I regret to have to say that the statistics for the month of May are by no means complete. Bibliographical work in connection with several scientific papers on which I was then engaged necessitated my absence from Grimsby during the early part of the month, and the sudden illness of my subordinate during the same period interfered with the arrangements I had made for keeping up the records. The statistics as to plaice are, therefore, a blank for the first week of May; Mr. Clark unfortunately remained unwell for the rest of the month, while a serious break-down in the circulating apparatus of the Cleethorpes aquarium made great demands upon the time which I should otherwise have been able to devote to market observations; and, though I was able to keep account of all plaice landed, my statistics as to haddock and cod are too meagre to be worth insertion. The gas-engine for water circulation was finally restored to good working order, but, to guard against any future temporary break-down, I have fitted the entire series of sea-water tanks with an apparatus for air circulation, on a pattern communicated to me by Dr. G. H. Fowler.

It has proved that this air circulation is quite sufficient to keep the tanks properly aërated throughout the night, and we have thus been able to save the excessive labour and expense (for gas) which the smallness of our reservoir had hitherto entailed in pumping by night as well as by day.

Plaice.—The statistics are continued from the end of April, 1894; as stated above, the eight days missed in May were at the beginning of the month.

Month.	Total No. of Boxes.	North Sea.			Iceland.	
		Total.	"Large."	"Small."	No. of Boxes.	No. of "Voyages."
1894.	I.	II.	III.	IV.	V.	VI.
May (less 8 days) ……	12,729	9,612	5,393	4,219	3,117	25
June ……	15,939	13,181	8,439	4,742	2,758	21
July (less 3 days) ……	14,304	11,295	9,034	2,261	3,009	19
August (less 1 day) …	16,616	15,950	14,617	1,333	666	5
September (less 3 days)	15,503	15,503	14,663	840	…	…

In the last number of this Journal (p. 171) I entered at some length into the question of the diversion of fishing power from one point to another, which is revealed by comparison of the different columns in the above table. The same reasoning is of course applicable to the present season; and while we note from the close similarity of column IV in 1893 and 1894 that the "small" fish grounds were worked to about the same extent in the two years, the great diminution of column VI in July and August of 1894 shows that considerably more power was available in those months for the augmentation of column III. There is an actual increase of about 3000 boxes in the aggregate of the two months in 1894; but such an increase is of no great significance when we take into account not only the number of boats available from the diminution of column VI, but also the steady annual increase in trawling power generally. It will have been gathered from my previous remarks that the Iceland grounds are worked by steam vessels only (as far as trawling is concerned), while the "small" fish are chiefly contributed in the later part of the summer by fleets of sailing smacks. During the present year the usual practice of forming a large fleet, to land fish by steam cutters at London, has been discontinued, so that during the fleeting season the number of vessels landing at Grimsby has been proportionately greater. A very large Fishing Company belonging to the port habitually "fleets" throughout the year, its fish being landed in London, and therefore finding no place in my records.*

The Iceland trawl fishery cannot be said to have been satisfactory during the present season. In the early part, especially in May, boats had for the first time a difficulty in finding their fish. In previous years the only difficulty had been in getting a fair price for them, but, out of twenty-five "voyages" in May, twenty averaged but little more than 100 boxes each. Later on matters improved somewhat, but at no period were the fish to be found in the same abundance as last year, while, as I am informed, some of the best grounds were practically "cleaned out." To some extent, no doubt, on this account, but largely also on account of the higher price obtainable for the smaller inshore fish, there appears to have been a very general disregard of the territorial regulations of the Danish Government, with the result that one or two vessels were seized and heavily fined. This had the effect of bringing the season to an earlier close than last year, and, as the Iceland Parliament passed a bill early in September enforcing still heavier penalties on territorial trawling, it may be supposed that the inshore grounds will be little molested in future years. The penalties under the new law are as follows:

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* A cutter occasionally lands at Grimsby when coming in for stores or other purpose, but I do not include the fish in these returns, since to do so would tend to confusion in the deduction of results.

For the first offence . . .	2,000 crowns, £100 each.
For the second offence . . .	10,000 crowns, £500 each.
For the third offence . . .	Confiscation of the vessel.

On a coast where the declivity is rapid the three-mile limit is far from being the natural one, but no fault can be found with the authorities for availing themselves of all the protection which international law allows them.

Haddock.—The appended figures show the total number of "small" fish landed during the months specified:

June (less 1 day) . . .	5570	boxes.
July	6039	,,
August (less 2 days) . .	6798	,,
September	6587	,,

Comparison with the same months of last year (*supra*, pp. 128 and 174) shows a large increase for the present year, which increase, it may be mentioned, is being maintained in the later part of the season. Indeed, I am given to understand that haddock are now more plentiful than they have been for a great number of years, and there has certainly been a steady augmentation ever since these statistics were commenced. My figures deal only with "small" fish, but I have no evidence of any diminution in the supply of fish of all sizes, and however the haddock may have suffered from overfishing in the past, it apparently holds its own at present. The exceptionally large catches of the autumn and winter of this year may possibly be to a great extent dependent on the favorable weather of 1893. Bottemanne has clearly established the dependence of the anchovy supply of any year on the temperature of the previous year;* and though there exists no series of observations to support the same conclusions with regard to any other fish, it is at least possible that the principle is capable of a wider interpretation. Fishermen hold the opinion that a warm spring means a good supply of fish of all sorts in the autumn of the *same* year, but the experience of 1893 can hardly be said to have given any very great support to this view. It must be remembered, however, that the advantages of a good supply of fish may be seriously discounted by weather unfavorable to their capture; while, on the contrary, as during the present autumn, an open season permits of catches which may make the supply appear *relatively* greater than it actually is.

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* Cf. Dr. Fowler's epitome of Bottemanne's researches (*supra*, vol. i, N.S., p. 340).

Cod.—Trawled codling, of the size explained in previous records, have been landed in the following numbers:

June (less 1 day) . . .	354	boxes.
July	1708	,,
August (less 2 days) . .	2140	,,
September	2636	,,

The most noteworthy feature is the lowness of the returns for June. April (*supra*, p. 175) was also somewhat unproductive, and fish were certainly scarce in May. I have already alluded to the general opinion that codling are comparatively scarce (in the trawl) in summer, and comparison of the different months shows that the least productive period of each year has been from April to June (inclusive).

Inshore Fisheries.—I referred in my last report to the unusually large catches of prawns (Pandalus), shrimps and small plaice, &c., made in the Humber last summer. It was attributed by fishermen to the fine warm weather, and I considered it probable that the good effects of such weather would continue to be felt in the summer of the present year. There has been, however, at the best only a moderate supply of prawns and shrimps this year, while "flat-fish," *i. e.* young plaice, have been remarkably scarce, though the same cannot be said of soles. Indeed, from observations which I was able to make on board the s.s. "Garland," both this year and last, I believe that there has been a distinct improvement in the supply of soles in the river. Comparatively few were brought to market, owing to the energetic action of the local fisheries authorities in enforcing their bye-laws with regard to fish trawling in the river, and to this action the increase may to some extent be due. It may be explained that soles are likely to receive the most protection from this legislation, because they are the fish to which the fish trawlers were wont to devote the bulk of their attention as long as they were permitted to do so, and the greatest number of soles are found in parts of the river not much frequented by other flat-fish.

Note on some Supposed Hybrids between the Turbot and the Brill.

By

Ernest W. L. Holt.

The specimens conform to a type which appears to be fairly well known to Grimsby fishermen and fish merchants, and which is always regarded by them as the offspring of the parents mentioned in the title. The object of the present note is to discuss the probabilities of the correctness of this diagnosis as fully as the material allows. The form can hardly be said to be rare, since within two years I have secured three specimens, while I have heard of several others having been present in the market. In some old manuscript notes kindly lent me by my friend Mr. G. L. Alward I find descriptions which apply to two fish of the same type, while Dr. Günther tells me that he has received several from London fish merchants.

Notes of apparently similar fish have from time to time appeared in both scientific and sporting publications, since Day (Fish G. Brit., ii, p. 13) refers to specimens described in the Proceedings of the Zoological Society and the Field, while Smitt has recently given both description and figure (Hist. Skand. Fish., ed. 2, p. 446).

Description of Specimens.

The specimens which have come under my own observation are three in number; they were trawled in the North Sea, one in June, 1892, and the others in the same month of the following year.

Colour.—In the fresh condition they presented so close a resemblance in colour to brill that they might easily have been mistaken for a fish of that species. The brill, as is well known, is of a reddish-brown colour on the ocular side, diversified with sundry lighter markings, which markings are retained to some extent after death. The turbot, on the other hand, as it appears in the market, is of nearly uniform olive-brown colour, the lighter markings conspicuous in living examples being rapidly masked by post-mortem expansion of the darker chromatophores. Specimens of the two species may certainly be found to approach each other in general coloration, but it will be conceded that the broad distinction which I have laid down holds good in the majority of cases. Preservation in alcohol rather emphasises the distinction in the case of brill and turbot, but, of the three hybrids, one acquired after preservation a colour corresponding to that of a turbot similarly preserved, while the other two retained the reddish tinge of the brill.

Scales.—The character of the scales forms the most striking feature in the three specimens, and is practically identical in all. In place of the imbricating scales of the brill or the isolated tubercles of the turbot, both sides of the body are beset with large more or less oval, cycloidal scales, which, though never actually imbricating, are placed fairly close together. On the ocular side of the body each scale is very thin and slightly convex, the most prominent part being at the central point of the concentric system of faintly marked ridges situate behind the middle line of the scale. The larger scales exhibit a number of faint grooves for insertion anteriorly, but there is no free edge. The whole scale is between two pigmented layers of dermis, but the upper layer on the ocular side is in most cases incomplete at the greatest convexity of the scale, so that the latter is, to that limited extent, exposed. The skin is so thin that it might readily be abraded, and to what extent the partial exposure of the scales may be due to artificial causes (*e. g.* injury in the trawl, &c.) it is impossible to say. The largest scales occur on the lateral parts, especially on the caudal peduncle, and anteriorly in the neighbourhood of the lateral line. In a specimen of 43·3 cm., one of the largest from this region measures 5 by 3·5 mm. Towards the abdominal region the scales become smaller and irregularly rounded, as also on parts of the interspinous ridges. On the jaws they are small and circular, rather small and nearly round on the head, except on the malar part, where they become larger and elongate. On the fin-rays the scales are very small, and here alone they show some attempt at imbrication. On the blind side the scales are essentially similar to those of the ocular side, but are less convex and almost invariably veiled by skin. They correspond in distribution, with the exception that there are only a few on the mandible and none on the maxilla or the prominent parts of the gill-cover, while the fin-rays are only feebly scaled.

Dimensions.—Of the three specimens two were measured after preservation, the third being measured both in the fresh and preserved conditions.

	Total length.	Total without caudal.	Length of head.	Greatest height.
A.	$17\frac{3}{8}$ in.	14 in.	$4\frac{5}{8}$ in.	$9\frac{19}{32}$ in.
B.	$18\frac{1}{8}$ in.	$15\frac{1}{4}$ in.	$4\frac{7}{8}$ in.	$9\frac{1}{2}$ in.
C (*preserved*)	$18\frac{3}{4}$ in.	$15\frac{13}{16}$ in.	5 in.	$10\frac{3}{8}$ in.
C (*fresh*)	19 in.	16 in.	5 in.	$10\frac{1}{2}$ in.

Fin-ray Formula :

A.	D. 69	A. 52.
B.	D. 72	A. 54.
C.	D. 76	A. 54.

Comparative.—The foregoing description will probably suffice, minor details of character being more conveniently treated only in comparison to those of the species to the union of which the forms before us have been imputed. It may at once be said that all three examples are females, but not one of them is sexually mature. It is significant that all three were caught in the month of June, a period at which the ovary would certainly be enlarged (or evidently recently shotten) in either brill or turbot, and fish of either species as large as those before us (viz. $17\frac{1}{8}$ to 19 inches) would as a rule be sexually mature. In fact, an immature female brill of even the smallest size quoted is decidedly rare. Apart from the scales, turbot and brill are most readily distinguished by the proportion borne by the height to the length of the body, the turbot being the deeper fish of the two. The proportions laid down in ichthyological works, however, are of no great service, since the size of the individuals on which such proportions are based is never forthcoming, and it is well known that the proportions of a fish are subject to constant change with the growth. Therefore, in comparing our supposed hybrids with the brill and turbot, it appeared best to give the proportions of a series of forms of either species agreeing as nearly as possible with them in size, as in the appended table. The total length, without the caudal, given in the first column is taken as the unit, and the other dimensions are expressed in decimals of this unit.

	Total length without caudal, in inches.	Length of head.	Greatest height of body.
Hybrid A	14	·330	·685
„ B	$15\frac{1}{4}$	·336	·622
„ C*	$15\frac{13}{16}$	·316	·656
„ C†	16	·312	·656
Brill i	$10\frac{1}{8}$	·358	·679
„ ii	11	·295	·608
„ iii	11	·295	·586
„ iv	$11\frac{1}{4}$	·288	·600
„ v	$11\frac{3}{4}$	·295	·675
„ vi	12	·291	·562
„ vii	$14\frac{7}{8}$	·302	·571
„ viii	$15\frac{1}{2}$	·306	·516
„ ix	16	·281	·562

* Fresh. † Preserved in alcohol.

	Total length without caudal in inches.	Length of head.	Greatest height of body.
Turbot i	13¼	·349	·660
„ ii	13¼	·339	·688
„ iii	13½	·342	·750
„ iv	13½	·351	·722
„ v	14	·357	·732
„ vi	14¼	·333	·719
„ vii	14⅜	·347	·695
„ viii	14⅝	·341	·700
„ ix	14¾	·336	·711
„ x	14⅞	·344	·710
„ xi	15	·358	·766
„ xii	15½	·354	·677
„ xiii	15¾	·349	·730
„ xiv	16½	·333	·666

The details of proportion of brill and turbot given in the above table show how easily a diagnosis based on these features alone may be vitiated by individual variation; but, on the whole, the condition exhibited by the hybrids appears to be an intermediate one, not inclining very strongly to either species. It must be remarked that the measurements from which the proportions of the brill and turbot are deduced were taken in the fresh condition, but comparison of the two series of proportions of hybrid C shows that the figures are not greatly affected by preservation in alcohol. The variation which is exhibited by the hybrids amongst themselves is evidently not greater than is met with in perfectly normal examples of either species.

The fin-ray formula given above is certainly intermediate in character, but inclines, among material collected from the same locality, rather to the brill than the turbot. Thus nine turbot give D. 60—67, A. 42—48; the three hybrids D. 69—76, A. 52—54; and four brill D. 77—81, A. 57—62. The first dorsal ray is in each case shorter than the second, as in turbot, but its extremity is divided, as in the brill.

The number of vertebræ is an important distinction between the turbot and the brill. The only hybrid in which I have counted these structures agrees in this respect with the last-named species.

In certain minor characters of doubtful importance the hybrids appear to be intermediate. The vomerine teeth are rather more numerous in the brill than in the hybrids, and much more numerous than in those turbot which I have examined. In the teeth of the upper jaw the hybrids agree best with the brill, the teeth being more slender than those of the turbot. The peculiar papillation of the lips is probably a very variable character. Such turbot as I have examined have an outer row of semicircular pigmented labial tags or papillæ; this feature was slightly represented in the hybrids, but absent from the brill. A strong inflection of the dorsal profile behind the snout is noticeable in all turbot. It is, at best, but slightly marked in the brill, and in this the hybrids agree with the last-named species.

As will be gathered from the description, the scales of the supposed hybrids differ at first sight very markedly from those of either the turbot or the brill, resembling rather the smaller non-imbricating skin-clad scales met with in the plaice, and especially in large examples. The resemblance to either brill or turbot only becomes apparent when we come to consider the real nature of the dermal apparatus of the last-named species. The turbot, as is well known, is clad in a deeply wrinkled skin, the wrinkles, on close inspection, being the depressions or sulci which separate a very irregularly arranged series of rather vesicular papillæ. Scales are only represented by a series of tubes, with very imperfect dorsal and ventral flanges, in connection with the sense-organs of the lateral line, and by large isolated tubercles, the apices or bosses of which are naked, while the bases are deeply embedded in the derma by a series of twisted irregular radical processes. Such tubercles in British examples are present only on the ocular side, except in "cyclopean" or in partially ambicolorate fish, in which they occur also to a greater or less extent on the blind side. In Norwegian fish, however, the tubercles, which are as a rule more numerous on the ocular side than in examples from our own seas, occur not infrequently on the blind side without any accompanying pigmentation. The skin papillæ and wrinkles are equally present on either side in all examples.

On the general surface of the body there is no very striking resemblance between the papillæ of the turbot and the scale capsules of the hybrid, but at the base of the interspinous ridges the skin of the two forms presents a fairly close resemblance, and I was led by this to institute a comparison of the skin armour of the two forms, which led me ultimately to the conclusion that the papillæ of the turbot's skin were undoubtedly scale-capsules, in which the scales had failed to develop. This view I believed to be novel, but on the appearance of Professor Smitt's edition of Fries, Ekstrom, and Van Wright's History of Skandinavian Fishes I found it set forth (p. 434) that the skin is furnished with "soft verrucose closed scale-sacs." This interpretation of the papillæ may either be original, or, since the work in question is largely a compilation, may be collated from the observations of some earlier Skandinavian ichthyologist. I am entirely in accord with it, but, if it is set forth for the first time in the work referred to, it runs the risk of rejection for want of evidence, since the matter is nowhere alluded to in the context. I propose, therefore, to discuss the question very briefly in this note.

In the appended woodcut, Fig. 2, *a* is a group of scales and capsules from the lateral line of a hybrid (blind side), and the resemblance to true scale capsules of the lateral line of the normal turbot is sufficiently noticeable. The surrounding scale capsules, however, are far more regular than the papillæ of the turbot, besides enclosing a very conspicuous ovoidal scale. In a group of scales (*b*) from the base of the interhæmal ridge of a hybrid (blind side) we find that the sulci, in this case obviously in connection with true scale capsules, present an appearance closely similar to those met with between the papillæ of the same region in the turbot. *c* shows a single tubercle of a nearly adult turbot (ocular side) surrounded by a group of papillæ, the apex of the tubercle projecting through the skin in precisely the same manner as I have described in the case of some of the scales of the ocular side in the hybrids. The smallest turbot ($4\frac{7}{8}$ inches) in which I have found the tubercles visible to the naked eye has these structures in the form of blunt cones, the bases of which are elongated anteriorly, but entirely destitute of radical processes. Radial insertion sulci are also absent, but such is also the case in some scales of the hybrid. In fact, save that it is much thicker in proportion, the young tubercle of the turbot is not distinguishable in structure from the scale of the hybrid. The tubercles of the turbot, as is well known, have no regularity either of disposition or of number, and I think that there can be little doubt but that the intervening papillæ are merely barren scale-sacs, which become to some extent broken up and anastomosed with the growth of the fish. If this is the case the intermediate nature of the scales of the hybrid becomes apparent.

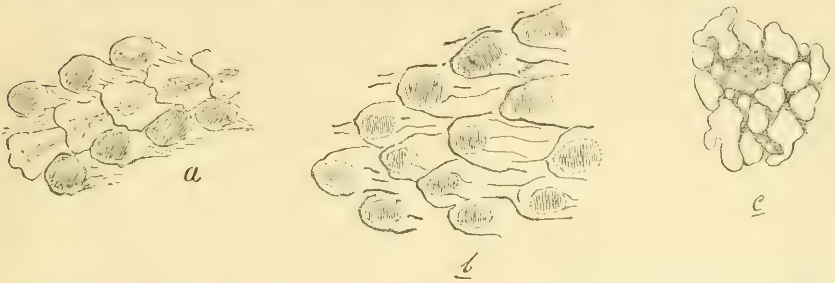

FIG. 2.—*a.* Group of scales from region of lateral line of hybrid (blind side). *b.* Group of scales from base of interhæmal ridge of hybrid (blind side). *c.* Tubercle and surrounding papillæ of turbot (ocular side); pigment omitted from papillæ.

More sparingly distributed than those of the brill, though more numerous than in even the most thickly tubercled Norwegian turbot, the scales retain characters which closely resemble a very early condition in the development of a turbot's tubercle, as well as the perfect condition of the scale of a brill. The persistence of the skinny covering has probably no greater significance than is explained by the comparative remoteness of the scales, since the imbrication and exposure of the free edges of the scales in the brill may be taken as the result of the closeness with which they are set in that form.

Perhaps the intermediate character is best brought out by comparison of the scales of the lateral line in the three forms. The body of the scale, represented in the turbot by very insignificant flanges, dorsal and ventral to the sensory tube, is present in the hybrid to a variable extent, as may be judged from comparison of *b* and *c* (Fig. 3). In no case is it so well developed as in the brill (*a*), nor so insignificant as in the turbot (*d*).

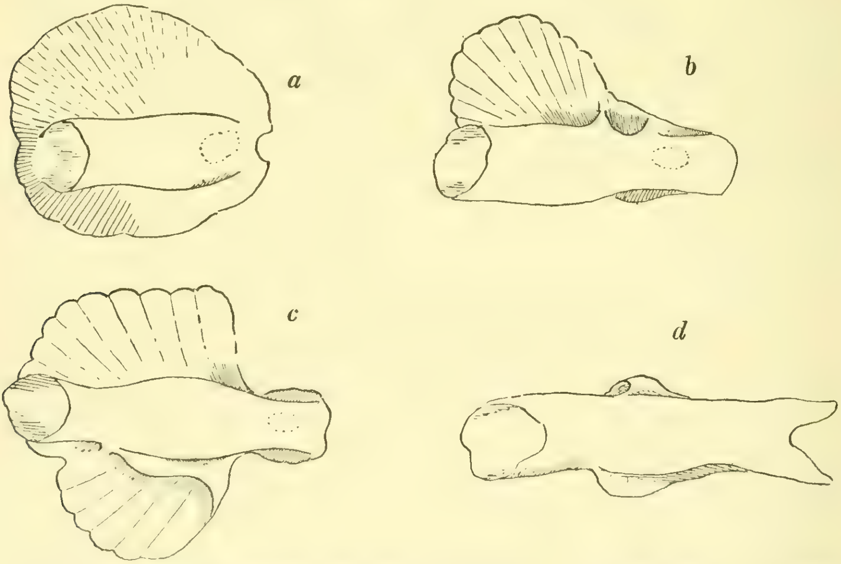

FIG. 3.—*a*. Scale from lateral line of brill (blind side). *b*, *c*. From hybrid (blind side) *d*. From turbot (blind side).

Conclusions.—In discussing the parentage of these forms it appears to me that there are only two alternative theories, since it is not likely to be seriously contended that they belong to a distinct species. They may be either hybrids, or "sports" of either the turbot or the brill. If the latter is the true explanation it is at least remarkable that the variation should in so many points tend towards the typical characters of another species, and I cannot but think that the sexual immaturity of all three specimens (considering their large size) is strong evidence of hybridity. As to whether the female parent was brill or turbot there is little evidence, but perhaps the preponderance of brill-like characters seems to point to the former species. Within the limits of a single species (*e. g. Salmo levenensis*) it is the characters (of size and pigmentation) of the female parent that are reproduced in the offspring (Sir J. Gibson Maitland, Bart., *in litt.*), and it is not unreasonable to suppose that the species of that parent may be predominant in determining the characters of a hybrid. Ova of the brill have been successfully impregnated with the milt of the turbot by Professor M'Intosh, and although the larvæ proved delicate, they do not appear to have been less hardy than pure-bred turbot larvæ which have come under my own observation.

Of the several instances of supposed hybrids collected by Smith (*op. cit.*, pp. 444 and 446) all seem to have been somewhat turbot-like in shape, and the author's conjectures as to the parentage seem to be based chiefly on the number of fin-rays and the relative thickness of the scales. The form which appears to correspond most nearly to those which form the subject of this note is suggested to be the result of the union of the male turbot and female brill, and on the whole I am inclined to think that this interpretation of the parentage is correct.

The Migration of the Anchovy.

Summary of a Report to the Council of the Association.

By

J. T. Cunningham, M.A.

The facts gathered up to the present time with regard to the occurrence of anchovies in the English Channel are briefly as follows:

In November, 1889,* large numbers of anchovies were reported to have been taken at Dover in the drift-nets used for sprat fishing. During the same month also numbers were taken by the sprat fishermen in Torbay, in seines.

In the following November, 1890, numbers of anchovies were brought in at Plymouth by pilchard fishermen, fishing to the south of the Eddystone. On November 26th one boat took 584, and on November 27th one took 500. During this autumn nothing was heard of anchovies at Torquay, and Mr. Matthias Dunn could not obtain any at Mevagissey.

The only anchovies brought to the Laboratory in the autumn of 1891 were caught on November 9th. On this occasion twenty-one fish were counted. No anchovies were reported from Torquay. Anchovy nets purchased by the Association were shot twenty-four times between September, 1891, and April, 1892, and thirty-one anchovies were taken, the largest catch being twenty on November 20th.

During the winter 1892–3 the number of anchovies obtained from fishing boats at Plymouth was sixty-one, of which number thirty-three were caught in November and December. The Association's nets were shot six times in November and December, and five anchovies were taken, all at one time (November 28th).

During the winter 1893–4 only eight anchovies were obtained from the Plymouth fishermen. The nets of the Association were shot once, but no anchovies were caught. No anchovies were reported from Torquay.

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* This Journal, vol. i, N.S., p. 334.

In November and December, 1894, twenty-seven anchovies were obtained from Plymouth fishermen. The Association's nets were shot five times in November, but no anchovies were caught, and it was definitely ascertained that none were taken at Torquay.

My general conclusions from the facts known concerning the anchovy are as follows:

It seems at present most probable that the anchovies which spawn on the Dutch coast in June and July are those which are found in the English Channel in autumn and winter. We do not know of any spawning places of this fish on the west coast of Europe, except the east side of the North Sea. The spawn has been observed in the Zuyder Zee and in the open sea near Nordeney by Ehrenbaum. We have not seen any anchovy spawn in the neighbourhood of Plymouth, and there is no evidence of the presence of anchovies in that locality in summer. But anchovies are caught on the French shore of the Bay of Biscay, at any rate in the southern part. We do not know if they spawn there. If, then, the anchovies in the Channel move north in summer when they spawn, how is it that their place is not taken by other anchovies coming up from the south?

The reply to this question is probably given by the peculiar distribution of summer and winter temperature. There is a much greater range of temperature in the shallow estuaries and basins on the coast of Holland than in the deeper water at the entrance to the English Channel. On the chart of temperatures of the Atlantic, published by the Meteorological Office, the August temperature near Plymouth is 61° to 62°, and outside the Frisian Islands it is marked 62°, 63°, and near Heligoland 65°. The temperature in the Zuyder Zee is higher in summer than that of the sea outside. We know from the Dutch observations that in 1887 the seven days' mean temperature at 7 p.m. in the Zuyder Zee in July varied from 62·6° to 66·2°. According to observations published by Mr. Dickson in this Journal, vol. ii, p. 276, the ten days' mean off Plymouth in July, 1891, was 57·2° to 57·4°. In the same year the seven days' mean of the surface water in the Zuyder Zee was in July 62·2° to 63·3°.

In 1892 the surface temperature in February, ten days' mean, according to Mr. Dickson, was 44·1° to 46·4°. In the Zuyder Zee for the same month it was 33·9° to 39·0°.

It is clear, therefore, that the water on the coast of Holland is warmer in summer and colder in winter than that of the English Channel. This explains why anchovies do not spawn in the Channel. A temperature equal to that on the coast of Holland in summer is only obtained further south on the French coast, where anchovies are taken in summer, and where they probably spawn. We know that there are anchovies in autumn and winter at the western end of the English Channel; these, in order to reach a temperature high enough for spawning, must go either north or south. It seems probable that all these anchovies come from Holland and return thither.

In relation to this probable migration it is interesting to compare the statistics of the Dutch fishery with the evidence we have obtained of the varying abundance of anchovies in the neighbourhood of Plymouth. The following are the temperatures in July in the Zuyder Zee, and the total yield of the anchovy fishery in that sea in successive years:

	Temperature in July.	Ankers of Anchovies salted.
1882	14·7° to 16·7° C.	18,736
1889	16·8° to 18·9°	1,676
1890	15·4° to 18·3°	194,096
1891	16·8° to 17·3°	45,914
1892	16·2° to 17·7°	6,854
1893	17·7° to 20·1°	13,908

Now we first heard of anchovies in connection with the M. B. A. in November, 1889, when large numbers were seen at Dover, large numbers were taken in the sprat seines at Torquay, and samples were brought to the Laboratory by the pilchard fishers at Plymouth. In the previous summer very few had been caught in the Zuyder Zee, although the temperature in that summer was high. But in the following summer, with a similar temperature in the Zuyder Zee, one of the maximum catches was made there. In the winter of 1890 anchovies were abundant in the Channel; I obtained 1000 from pilchard-nets in two days in November, and again in the following summer a fairly large catch was made in the Zuyder Zee. In the winter of 1891 and 1892 anchovies were not plentiful off Plymouth, and in the following summers the catch in the Zuyder Zee was small.

The fact that so few anchovies were taken in the Zuyder Zee in 1889, while in the following autumn they were so abundant in the Channel, is difficult to reconcile with the theory that the winter anchovies in the Channel come from the coast of Holland. It is possible that there is another explanation, namely, that in warm winters the anchovies come northward to the Channel, and in a warm summer following pass up to the warm waters of the Dutch coast, where they are crowded together in narrow waters, and so give opportunity for a fishery. If this suggestion were correct the prosperity of the Zuyder Zee fishery would depend not, as Prof.

Hoffmann supposed, on the warm summer of the year before, but on the mildness of the winter in the Channel. This suggestion can be tested by an examination of the meteorological conditions during past years in comparison with the statistics of the Dutch fishery.

I would suggest that in future a careful record should be kept of the meteorological conditions, temperature of the sea, and number of anchovies obtained at Plymouth, in order that the law of the anchovy fisheries might be ascertained. I would further suggest that endeavours be made to obtain data concerning the natural history of the anchovy on the west coast of France, and north and west coasts of the Spanish Peninsula. We do not know at present whether the fish spawns there, and in what abundance it occurs at different seasons. If these matters have not yet been ascertained, it would not be difficult by communications in the proper quarters to get observations on them made by competent naturalists in the countries concerned, or it might even be advisable to send a naturalist from England for the purpose.

In conclusion I would say a few words on the question of an English anchovy fishery. As far as our evidence goes—and it is fairly extensive—there has been no possibility of a profitable fishery except in the years 1889 and 1890. In the former year a considerable number of anchovies could have been cured at Torquay, and in the latter a smaller number at Plymouth; but there is no indication that enough anchovies could be caught in the Channel to recompense the employment of special nets for their capture alone. My own opinion is that the fish are either too much scattered or too far from the coast to be caught in very large numbers. In Holland it is different; the fish are there crowded into a small area.

On the other hand, I think it would be advisable to ascertain whether small pilchards occur off the Cornish coast in summer in sufficient numbers to support a sardine industry like that of the west coast of France. The pilchard fishery is unprosperous, the market for large salted pilchards is bad. There is a factory at Mevagissey where large pilchards are imperfectly preserved as sardines, but the flavour of sardines depends on the size, as lamb is more delicate than mutton. If small pilchards are to be caught on the Cornish coast in large numbers in summer, there is no reason why the French sardine industry should not be extended to Cornwall, and prove a great boon to the population, whose resources in mining and fishing have been much reduced. To this end I would advise that our small-meshed nets be shot regularly throughout the months of April, May, June, July, August, and September, and all the results examined and recorded.

On the Oxidation of Ammonia in Sea Water.

By

G. P. Darnell-Smith, B.Sc., F.C.S.

Whilst working at the Laboratory this summer on the function of iodine in Algæ, it was suggested to me by the Director that I should study the influence of Algæ on the ammonia in sea water. I here tender my thanks to Mr. E. J. Bles for his kind advice and assistance.

Before commencing experiments with Algæ the effect of keeping sea water in the light and in the dark was tried. Neither daylight nor darkness appears to have any effect on the amount of ammonia in the water. Thus—

Sea water containing . .	·002	grm. NH_3	per 100 litres,
After standing in the dark twenty-four hours contained . . .	·0025	,,	,,
After standing in the dark forty-eight hours contained . .	·002	,,	,,
Sea water containing . . .	·001	,,	,,
After standing in the light eight hours contained . . .	·001	,,	,,
After standing in the light sixteen hours contained . . .	·001	,,	,,

After a few days, however, whether standing in daylight or darkness, ammonia is produced by the decomposition of organic matter.

In order to test the efficiency of Algæ in oxidising the ammonia, sea water which had been in an inverted bell-jar seven days, with a fair quantity of Ulva, moderately illuminated, was analysed.

It contained	·0376	grm. NH_3	per 100 litres.
After being placed in the window twenty-four hours it contained .	·010	,,	,,
After being placed in the window forty-eight hours it contained .	·009	,,	,,

This rapid reduction of ammonia is probably due to the oxygen given off by the Ulva. To check this conclusion, water containing ·008 grm. NH$_3$ per 100 litres was placed in a bell-jar in the dark and a quantity of Ulva placed in it.

After twenty hours it contained	·008	grm. NH$_3$	per 100 litres.
After forty ,, ,,	·008	,,	,,

Thus when assimilation was not proceeding the quantity of ammonia remained stationary. Decomposition then commenced, for—

After standing in the dark sixty-four hours it contained	·012	grm. NH$_3$	per 100 litres.
After standing in the dark eighty-eight hours it contained	·030	,,	,,

The jar was now placed in the window, and after standing there forty-eight hours it contained ·007 grm. NH$_3$ per 100 litres. That the reduction of ammonia in sea water by Ulva depends upon the assimilation of the latter is further shown by the following experiments. Water, into which some Ulva had been put, had stood seven days in a position moderately illuminated.

It contained	·037	grm. NH$_3$	per 100 litres.
After standing in the window twenty-four hours it contained	·009	,,	,,
After standing in the window forty-eight hours it contained	·010	,,	,,
After standing in the window seventy-two hours it contained	·015	,,	,,

The available carbon dioxide had apparently been used up after the first twenty-four hours, and the plant was unable then to keep down the ammonia. A small quantity of carbon dioxide was now blown through the water, and after twelve hours it contained ·009 grm. NH$_3$ per 100 litres. A further quantity of carbon dioxide was blown through overnight, and after standing seven hours in daylight the water contained ·006 grm. NH$_3$ per 100 litres. That the reduction in the amount of ammonia was not due to the agitation of the water is shown by the following experiment. Water containing much ammonia was placed with Ulva in bright sunshine.

It contained at the commencement	·009	grm. NH$_3$	per 100 litres ;
,, after five hours	·003	,,	,,
,, after forty-one hours	·006	,,	,,

showing the same series of changes as in the previous experiment. Carbonic acid gas was now blown through it, and it was still found to contain ·006 grm. NH_3 per 100 litres. After standing one night and six hours in daylight, however, it contained ·002 grm. NH_3 per 100 litres. The preceding experiments show that when Ulva is assimilating rapidly and oxygen is given off, the ammonia in sea water is very quickly reduced. The amount of carbonic acid gas, however, available for purposes of assimilation is not clear; from the "Challenger" Reports there does not appear to be any free carbonic acid gas in sea water, and Algæ, therefore, must depend upon that which is in a state of "loose" chemical combination.

An experiment was now made to test the rapidity of action of a current of air blown through the water. A current of air at the rate of 400 c.c. per minute was blown through sea water which contained—

At the commencement	·030	grm. NH_3	per 100 litres.
After five hours	·023	„	„
After twenty-six hours	·013	„	„
After fifty hours	·008	„	„

A second experiment gave similar results, and it appears, therefore, that the oxygen given off by Algæ is very much more efficacious than that of the atmosphere, which is probably due to its being in the nascent condition.

Remarks on Trawling.

By

Professor M'Intosh, M.D., LL.D., F.R.S., F.R.S.E.

FIRST SERIES.*

Reprinted, by permission of the Author, from the Twelfth Annual Report of the Fishery Board for Scotland.

I. General Remarks.

Fully ten years having elapsed since the Report on Trawling on the eastern shores was presented to the Trawling Commission (composed of the late Earl of Dalhousie, chairman; Right Hon. Edward Marjoribanks, M.P., now Lord Tweedmouth; Prof. Huxley; Mr. W. S. Caine, M.P.; and Mr., now Sir, T. F. Brady), it appears to be desirable to review the statements contained therein in the light of the information which the impetus given by the Commission has produced. Moreover this examination of results is all the more necessary, since last year another important body—viz. the Select Committee of the House of Commons on Fisheries, presided over by Mr. Majoribanks, M.P.—issued a new blue-book containing the finding of the Committee, and a mass of evidence.

In criticising this Report on Trawling, it is necessary to bear in mind that certain definite instructions were given by the Commission in regard to the hauls of the trawl. These fall under Section 6, and are as follow:—"The results of each haul of the trawl, so far as regards food-fishes, should be carefully registered, in order that positive data may be obtained.

"(*a*) As to the proportional quantity of immature fishes taken at various seasons.

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* I have to acknowledge, in the preparation of the "Remarks," the courtesy of Mr. Esslemont, Chairman of the Board; of Dr. Fulton; of Mr. W. C. Robertson, the secretary; of Mr. Couper, Fishery Officer, Aberdeen; of Messrs. Joseph Johnston and Sons, Montrose; of Mr. Scott, of the General Steam Fishing Company, Granton; and of the owners and captains of the various vessels, who invariably exerted themselves to furnish information. It was especially interesting to find some of the captains of the General Steam Fishing Company's ships, with whom I had worked in 1884, still at their posts.

"(*b*) As to the destruction of the spawn of food-fishes.

"(*c*) As to the proportion of live and dead fishes."

It is important to remember, also, that the choice of ground lay with the trawler in almost every case, and that the most productive ground, so far as could be ascertained, would in all probability be selected.

In the Report of 1884 the fishes were grouped into "saleable," "unsaleable," and "young," the latter term being synonymous with that now in general use, viz. "immature"—a term, indeed, which was introduced prominently in this Report. These three heads are well understood, and need cause no ambiguity, since even the fishing community are quite able to understand them—a size limit, of course, in every case having been considered. To the Royal Commissioners the fact that a young or immature dab was under 7 inches was not of great utility, but the number of such young forms was of the utmost importance in view of the statements then prevalent. Due care was taken to see personally that every example was authenticated, and if any weight is to be attached to the statement that the "great defect of the Report* is that no information whatever is given as to the limit of size dividing the saleable fish from the immature," there will be little difficulty in remedying it. Besides, it was not the scientific observer who regulated the sizes of the saleable fishes, but fishermen engaged in an industrial pursuit, and who had to bear in mind the demands of the public. Moreover a fish of a size that was saleable at St. Andrews might not be so at Aberdeen, and *vice versâ*, though, as a rule, the variation under this head was not great. According to the state of the market, again, fishes—*e.g.* gurnards—that were saleable at one season were unsaleable at another. As pointed out in the Report, "it is remarkable that so good a fish should be liable to variation in this respect, and that it should not always be taken to market, even during the height of the herring season." Frog-fishes even occasionally found a ready sale in the great central towns of England after the head, skin, and fins were removed; and in the Outer Hebrides dog-fishes formed, and still form, an important item in the crofters' diet-roll, the piles of skins in front of their huts being characteristic.

To take the fishes in the order in which they are mentioned in the Trawling Report, the following sizes formed the lower limit of the saleable fishes:—Skate (including grey, thornback, starry, sandy, &c.), 10—12 inches across the pectorals; herring, 7—8 inches, but those obtained were all much larger; codling (young cod), 8—10 inches, but no example so small occurred in the series;

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* Prof. Ray Lankester, *Sea Fisheries*, Chicago Exhibition, 1893, p. 64.

haddock, 8—9 inches,—when so small their price is insignificant, about 1s. per box; whiting, 8—9 inches; poor-cod, 7 inches; bib, 6—7 inches; coal-fish, 1 foot; hake, 1 foot, though seldom seen below 15 inches; ling, 15—20 inches; halibut, 13 inches; sail-fluke, 8 inches; craig-fluke (witch), 7 inches; long rough dab, 7 inches; turbot, 6—7 inches; brill, 7—8 inches; plaice, 7 inches; dab, 7 inches; lemon-dab, 7 inches; sole, 7 inches; flounder, 7 inches, rarely sold; grey gurnard, 9 inches; bream, 9—10 inches; cat-fish or wolf-fish, 15 inches, though all those obtained were large. By the term "saleable," of course, saleable in the food market is meant, since much smaller examples of every species might be utilised for manure, either as landed or after preparation in a factory.

In regard to the unsaleable round fishes, the remarks of the Commissioners of 1866 were—"It has never been alleged that ling, cod, and conger, in which the line fishermen are so largely interested, or mackerel, pilchards, or herrings, upon which the seine and drift fishermen depend, are caught by the trawl in an immature and uneatable condition." "Whiting and haddocks of small size, thought marketable, are taken by the trawl; but fish of similar dimensions are also captured by the liners, against whom, indeed, the charge of taking immature cod has especially been brought."

In the Report of 1884 it was stated that "a considerable number of young cod were present in most of the good hauls, but all were saleable fishes. Quite as many immature cod (codling) were caught by the liners in the same waters; and off the Bell Rock perhaps the proportion is even greater." The same state of matters exists at this moment. On the other hand, the number of very small haddocks caught by the liners, *e. g.* last year off the east coast of Scotland, far exceeded anything of the kind captured by trawlers. The one mode of fishing was as destructive to these immature forms as the other. The small fishes swarmed on the ground, and were caught in every haul of the liners just as they were swept into the trawl, but many of the smaller forms escaped from the latter through the meshes, while they were held fast by the hooks and so injured that, although they had been returned to the water, it is doubtful if they would have survived.

The remarks made then (1884) on the capture of very young cod and very young haddocks, therefore, remain suitable for to-day; and the same may be said of those on whiting, ling, hake, gurnards, coal-fishes, pollack, bib, and poor-cod. In the Trawling Report it was stated that large cod and other adult fishes were now seldom caught within the limits of the Bay of St. Andrews, and this was in accordance with the evidence then obtainable. The use of anemones as bait, together with the closure of the bay, shows that as many as sixty or eighty good cod are occasionally caught by a single boat, the lines being buoyed and left in the water all night. Some fine congers are also occasionally obtained off the east rocks. Moreover excellent haddocks are procured in the same area early in the year, and for two years small haddocks have abounded. Large green cod also occasionally leap out of the water in pursuit of their prey, and are captured on the beach, while a few pollack are got in the salmon-stake nets or on hooks. It would thus appear that further experience leads to a modification of the statement in the Trawling Report. How far the increase in numbers has been due to the closure and the absence of molestation, and how far to the fixed and extensive lines and special bait, are open questions.

The closure of the inshore waters—*e. g.* St. Andrews Bay—must have conduced to the prosperity of the turbot and the brill of that neighbourhood, most of the turbot (ranging from 9—11 inches) which formerly were captured by the trawlers (sailing and steam) now being unmolested, and reaching the outer waters when of some size. The salmon stake-nets, however, on the west sands still prove destructive to many turbot from $5\frac{1}{4}$ inches upwards. These small examples of this valuable fish are only used as bait for crab-pots. It is true the trawlers sweep the outer waters into which the young turbot and brill pass, but the area is wider, and the size of those captured considerably larger.

No fish formed the subject of greater solicitude in the Trawling Report than the plaice, both from its wide distribution and its great abundance, as well as from the supposed view that this was a form specially destroyed by the trawl, which had cleared out of St. Andrews Bay, for example, all the full-grown adults, and left only the smaller forms. It is apparent, therefore, that during the past nine years such inshore waters have had sufficient time for recuperation—at least to some extent—if these views can be maintained. The results of the trawling-work of the "Garland" up to 1892 have already been dealt with in this connection,* so that other observations, and the statistics of fishes captured by the liners in this area, have only to be considered. Without at present going into detail, it is found that comparatively few full-grown plaice are captured in the enclosed waters of St. Andrews Bay. Most of the large specimens that have occurred have been either diseased—*e. g.* blind or emaciated—or injured. An enormous number of immature or half-grown plaice, however, are reared in the area, and are captured by the liners, chiefly with lobworm, their lines being buoyed and left in the water for such periods as they please, relays of lines being often used. The success with which the local fishermen ply their trade in early spring amongst the plaice is indicated by the fact that a single haul of the lines of a small fishing-boat last February produced a sum of £9, and that a larger "catch" was procured by the same boat within the week. The closure of the inshore waters, therefore, while it places the trawl-fishermen at a disadvantage, benefits the line-fishermen, and does not deprive the public altogether of the supply of flat-fishes from the enclosed area. It does not, however, produce many large flat-fishes, for as these get older they appear to seek the deeper waters outside the limit, either from a natural habit, or as the result of constant interference by man. This habit, indeed, was noticed in the Report when dealing with the question of instituting the closure within the three-mile limit—thus :—"The flat-fishes, such as turbot, brill, plaice, soles, dabs, and thornback (skate) would certainly be left in comparative security in certain bays, as at St. Andrew's, the larger only, perhaps, seeking the grounds in the offing." These larger flat-fishes, many of which are mature (that is, spawning) are captured outside the three-mile limit in great numbers, and thus the supply of ova and young fishes for the inshore waters is affected, for, as previously pointed out, the latter waters depend to a large extent on the former in this respect. Few or no spawning plaice (none within our experience) are ever captured within the bay, though eggs and young in various stages are not uncommon. It is stated, however, that adult ripe plaice were formerly procured by hook and line off the rocky shore towards the mouth of the bay between Boarhills and Fife-Ness, on hard ground on which no trawl could work. The adult spawning plaice in greater numbers occur in the offshore waters, and, so far as known, there is no passage of these from the outer to the inner area for the purpose of discharging their eggs—as was formerly believed in regard to many fishes. If it had been for the advantage of the eggs and larval plaice that the adults should only spawn close inshore in the shallow water, there is no reason to doubt that such would have been the arrangement. It is apparent, however, that it is otherwise. Before reaching the shallow water of the bays the scattered ova have advanced towards hatching or have hatched, the majority probably in the latter condition, the open water being perhaps better suited for their safety. The yolk-sac of the larval fish is soon absorbed, the symmetrical post-larval condition is reached, by-and-by transformation occurs, and the little fish takes to the bottom, swarms being found in the muddy rock-pools towards the end of April and beginning of May. The life-history of this species would seem to show that—in dealing artificially with the eggs and larvæ—the most natural method is to place the larval fishes—just before the yolk-sac is absorbed—some distance from shore. They are more or less transparent, and will escape many of the dangers they run in such waters, and, before being carried close inshore, will either be transformed or about to be transformed, and more capable of escaping by their own exertions from their enemies. If the larvæ are placed in the sea close to a rocky beach or stretch of tidal sand or gravel, it is possible that many would be stranded by the tide. Therefore, though the observation that the young plaice (with eyes now on the right side) abound in spring in the shallow rock-pools and elsewhere is perfectly correct, it is no argument for placing the larval fishes in their neighbourhood, when in a truly pelagic condition. In the same way the spawning ling are found far from the inshore waters, their minute eggs being hatched in the open ocean, and the young stages passed long before reaching the margin of low water. The ling has not, indeed, been found in inshore waters till it reaches about 3 inches (3½) in length, and then in very limited numbers. It is more frequently secured when from 6 to 8 inches in length—at extreme low water at the margins of the rocks. As it gets larger it seeks the offshore, and thus, as in the plaice, there is a double migration—the wafting of the eggs, larval and young fishes shorewards, and the return of the adolescent and the larger forms seawards. A similar life-history appears to be present in many of the food-fishes—*e. g.* the turbot, brill, and halibut, though in the case of the dab, long rough dab, and some others there are marked exceptions, as pointed out in the Trawling Report. Thus, "the large proportion of immature dabs found 15 miles off St. Abb's Head is interesting, and shows that such are not confined to shallow bays like that of St. Andrew's. Moreover, the occurrence of relatively small specimens at this and even greater distances from land would raise a doubt as to whether all such young forms have been reared on a sandy beach inshore."* Since the foregoing was written, opportunities, by aid of the "Garland," for using the special trawl-like tow-net and the mid-water net near and at the bottom on the grounds 15 to 20 miles south-east of the Island of May, have been afforded, and great numbers of larval, post-larval, and young dabs, long rough dabs, and other forms have been obtained, thus confirming the opinion formerly expressed. Moreover, the trawling work of the "Garland" on its various stations from the Moray Firth to the Forth bear out the same conclusion. Again, the deeper water is the home of the post-larval frog-fish, even the pelagic eggs being rather uncommon near shore. The adolescent and adults, on the other hand, are frequent in shallow sandy bays like St. Andrew's.

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* A Brief Sketch of the Scottish Fisheries, 1882–92, p. 6.

* Report, Royal Commission on Trawling, p. 361.

It is apparent, from certain remarks in the preceding paragraph, that it is a mistake to say that the trawl alone can capture flat fishes. If the bait be suitable the lines are tolerably effective in regard to plaice, lemon-dabs, dabs, and flounders. Again, halibut-fishing (by hook) is the most productive method off the coasts of Iceland, Faröe, and elsewhere, and even the turbot and the sole are occasionally caught by the liners.

II. Changes in the Trawling-Vessels and their Apparatus.

With the exception of a few small sailing vessels and boats, trawling in Scottish waters is carried on, as it was in 1884, almost exclusively by steam-vessels; but, whereas at the latter period many of the vessels were old tugs or modified paddle-steamers formerly used for other purposes, most of the modern vessels, *e.g.* sailing from Granton and Aberdeen, are specially built for the purpose. The finest vessels do not cost much more than the serviceable vessels of the General Steam Fishing Company did in 1884, viz. £4,500, but very considerable improvements have occurred in the arrangement and equipment. Some of these iron ships are 100 to 120 feet between the perpendiculars, and considerably more on deck, with a depth of 10 to 12 feet. The paddle-ships at Montrose* are 116 feet between the perpendiculars, 21 feet broad and 10 feet deep; while the fine screw vessel is no less than 120 feet between the perpendiculars, 21 feet broad, and 11 feet 6 inches deep. The three latter have comparatively low bows, like many of the ships from Granton. The newer ships at Granton have also increased in size. Moreover, greatly increased height is given to the bow of the vessels at Aberdeen, so that the foot-hold on the fore-deck must be very uncertain, especially if slippery; but the water is kept out of the ship by such an arrangement. The after-part of the ship, however, is more or less flat, so that the trawls can easily be worked. These vessels range from 140 to 180 tons burthen, with engines from 40 to 65 horse-power.

Instead of having the steam-winch near the fore-cabin, in the newest ships it is placed on deck close to the engine-room, so that the steadiness of the ship is increased, and the bow kept out of the water. The screw-vessel at Montrose has two winches, one being behind the foremast, the other (smaller) behind the mainmast. The latter is very useful in discharging fishes and in working the dandy. In general, the Granton ships have the steam-winch in front, with the capstan behind, just before the engine-room—a different arrangement from that at Aberdeen. Moreover, a decided improvement is introduced by the presence of a "brake" in connection with this apparatus. In 1884 reliance was placed on the old hawser fixed to the trawl-warp in the case of the net being held by a sunken wreck or a rock. Now, the moment the net is fixed, the "brake" (which is secured to a moderate degree) permits the trawl-warp to run out, and thus save the net from serious rupture or total destruction while the ship is being stopped. In the Granton ships an iron wire rope is used instead of a hawser from a hook on the mainmast, to save rubbing on the rail. This is fixed to the trawl-warp by spun-yarn. The length of the trawl-warp, which is of steel-wire rope, ranges from 200 to 240 fathoms. The warp has six outer and a central strand. The older warps had a Manilla centre, but the newer have wire. A change has also been made in the teeth of the wheels of the winch, for instead of being transverse, they are now helical or oblique in such ships as the "Belcher." The warp is run round a capstan in rear, and out by a slit with rollers in the bulwarks of the ship. The large ends of the winch are used, as formerly, for winding the bridles and all ropes and tackle, the latter being still the method of hoisting on board the bag of the trawl. Instead, however, of the snatch-blocks being fixed to the deck, they now are attached to the top of the engine-room. A considerable number of the paddle-ships still use a 9-inch Manilla hawser as trawl-warp, and it is wound round a capstan from wheels beneath the deck. These also have the piece of old hawser (at Montrose of about 13 fathoms) as a guard during trawling, but, as indicated, the best screw-trawlers have the "brake" on the winch. In one or two of the older trawlers at Granton, the narrowness of the ship has caused the winch to be placed on the fore part longitudinally, not transversely.

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* Messrs. Joseph Johnston and Sons.

In some of the ships at Aberdeen the steering or wheel-house has a roof, with side-panels and panes, so as to protect the men, and it occupies the same position, viz. in the centre of the vessel. Others have simply a canvas shelter above the wood. In one of the newest vessels at Aberdeen, the steering-house is open, as it is stated the men are apt to sleep in the covered houses, and prefer to be in the open air during their watches, while it is interesting to note that the Granton General Steam Fishing Company's ships have always had open wooden wheel-houses. Besides a spirit-compass on a stand, a new vessel has an inverted one on a wooden pole, so that two are available in steering. Coals are still carried in the side-bunkers, which in the best ships have a floor of cement, so as to minimise the danger from fire. At Aberdeen small English coals are largely used,* and instead of being piled loosely on deck at starting, as in some of the vessels from Granton, the extra coals are stored in bags, and are thus more easily handled. The finest vessels carry about 60 tons of coal in the side-bunkers adjoining the engine-room, and burn about 2½ tons per diem, with surface-condensing boilers; but fairly good ships often exceed this quantity.* The consumption of coal in such cases is, of course, a vital point in the economy of the trade, and a vessel which will consume 60 tons in 12 days is seriously handicapped. Some think that the larger vessels, which require more coal, are less fitted for remunerative work, since they catch no greater number of fishes. They might, however, be safer at sea. An improvement is the placing of the iron water-tank, which will hold about 270 gallons, under the deck, thus economising space and avoiding accidents. It is filled by a hose-pipe fixed to a screw-hole on deck. In the large screw-vessel from Montrose the tank is placed behind the bulk-head of the engine-room, and a hand-pump raises water to the deck. In the newest ships an oil-tank, to hold from 40 to 50 gallons, is filled beneath deck in the same way.

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* At 11*s.* per ton.

The bulwarks of the new ships have self-acting scuppers for heavy seas, besides the usual small permanent ones, but no cement gutters are now present at the sides, as it was found that they were rather a disadvantage, for, in such as have seen service, the cement becomes dilapidated. In 1884 the ships working off Aberdeen usually carried their fishes in covered compartments at the bulwarks in front, or even permitted them to lie loosely on deck. This arrangement is now seldom seen, probably owing to the use of ice and the greater distances traversed. The bag of the trawl containing the fishes is emptied in the Aberdeen ships in a series of pounds (about 5 in number), formed by passing stout planks into upright grooves on deck in front of the winch, and in these the fishes are sorted and "gutted," preparatory to being placed in the fish-hold in ice. The labour involved by this method is a contrast to that of previous years off the eastern Scottish shores. Hence, when the catch at night includes haddocks of from 8 to 10 inches in length, these are considered unremunerative to treat in this way, and are thrown overboard.

In the ships of 1884 the stout boat of the trawler was either carried on deck or suspended from davits at the sides. They can be easily launched from the latter, but may be carried away, and, besides, the top weight of the vessel is increased. At Granton the vessels formerly described have now placed their boats on strong iron rails, 6 feet 6 inches high, on the starboard side, and bolted to the engine-room on one hand and the bulwarks on the other. Now a larger boat in the newer vessels is placed on rests in the centre of the ship over the engine-room, while in the most recent it occupies the centre of the stern, and the front "stock" or support has a swivel. Moreover, in the "Belcher" the hook of the chain-lashing is jointed and fastened with a ring, so that the boat can be made ready in a minute. The modern boat is considerably larger, and is covered with canvas.

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* This is much less than the quantity consumed by some of the old paddle-ships in 1884, *e.g.* about 35 tons a week.

In connection with the fittings on deck, the use of raised or projecting figures or letters of sheet-iron on the funnel is one of the modern changes; they are very easily seen at a distance. The initial letter of the owner is sometimes added. Each vessel is, of course, marked likewise on quarter and bow.

The ice-house, which had just been introduced in 1884, is now an important part of the vessel, usually in front of the fish-hold. Five tons of broken ice are taken in the larger vessels to the distant grounds. It is sent from the stores in barrels, and passed from the cart to the hold by a funnel. So important has this feature become, both for liners and trawlers—in Aberdeen, for instance—that special factories have been erected for the manufacture of ice by the ammonia system, about twenty tons being made daily in one* near the harbour at present, and extensions are in progress to manufacture forty tons daily. On the distant grounds, where most of the work of the larger vessels occurs, the ice is placed over the fishes after they are "gutted" and consigned to the hold, as was done by the English trawlers from the distant grounds in 1884. The price of ice (at present 17*s.* 6*d.* per ton) is thus an item of moment in the trawling expenditure. On discharging the fishes from Iceland, Faröe, or the Great Fisher Bank, the old ice is thrown overboard, and, though it might seem economical to keep it for use in a subsequent voyage, *e. g.* for the preservation of the offal, for which 10*s.* per ton is got from the manure companies, yet it is certainly the safer method. No wind-sails are now employed.

The fish-hold in the best ships is from 9 to 10 feet in height, divided into compartments, each with two shelves. In the "Southesk," a screw-vessel at Montrose, there are two holds. When fishes are stored with alternate layers of ice, the front of the compartment is closed with planks, unpainted or coated green with enamel-paint, which is readily purified by washing. The shelves, again, in each division, are useful in diminishing compression. This alone is a marked change on the Granton trawling-vessels of 1884, for the newest ships then had only an ice-chamber surrounding a central compartment in which the fish-boxes were placed. The smacks from Grimsby and other parts in England, it is true, used ice in the manner now described in 1884 and previously, but it was comparatively rare in Scotland at that period. It is necessitated now by the lengthened voyages to the more distant grounds.

* Mr. Lang's.

During the voyage the water which collects from the fishes and the melted ice is carefully pumped out by a "donkey" engine, so as to keep the fish-hold dry. The hold will contain about 700 boxes of fishes, and great care is taken to keep it pure. In the Granton General Steam Fishing Company's ships ice is not used during the winter, for the fishes can be carried fresh to the market by means of one ship acting as "carrier" daily. In the warmer weather, however, ice in bags is taken on board each vessel. Few ships at Granton, indeed, have the compartments for packing the fishes in ice, with the slips of board for closing them. This shows that the majority fish in the less distant waters.

In some of the newest vessels the accommodation for all the crew is in the aft-cabin, the fore part of the vessel being relegated to the fish-hold and stores. This appears to be a decided improvement in regard to the maintenance of a cool temperature and pure air near the fishes, especially when long voyages are undertaken. Formerly the crew had a fore-cabin, and the captain and mate an aft-cabin, and in many vessels the same arrangement still occurs.

The engine-room of the newer vessels is better ventilated, and the arrangements for the working of the engines facilitated. Even the ventilators are utilised for the hoisting of cinders from the hold by the aid of a small windlass. Moreover, in one the engine-room has an entrance from the galley as well as from the side—a convenience in stormy weather. A feature in contrasting the ships at Granton and Leith with those at Aberdeen is the small elevation of the engine-room above deck in the former.

In some ships the shrouds from the mizzen-mast are fastened to the deck about a yard from the bulwarks, so as to leave a clear space for working the trawl. In the larger ships, however, this is not necessary, the space in rear of the shrouds being sufficient for the trawl, or shrouds are altogether dispensed with, as in the Montrose paddle-ships, which have only a foremast.

The galley for the cook is in many under the bridge in front of the engine-room, or in some in the forecastle peak;[*] but in the Montrose paddle-ships it, with the water-tank, is at the side near the paddle. These also have two tow-rails, one in front of the cabin for the crew, and one behind the cabin for the captain (aft), as the vessels are used for towing. A hand-windlass for raising the anchor is also present.

The average length of the trawl-beam in the best ships is 54 feet, it being found that a longer beam does not work so satisfactorily or catch so many fishes. At Montrose the beam is 52 feet. As before, it is composed of two or three pieces of oak or French elm, though occasionally it is in a single piece, and has a diameter varying from 10 inches to a foot. The shape of the iron trawl-head is scarcely altered, the posterior iron plate in a few being somewhat more abrupt than in 1884, thus conforming to the English type of trawl. The height of the beam from the ground varies from 3 feet 8 inches to about 4 feet. The "Athole," one of the General Steam Fishing Company's ships, is at present provided with an "otter" trawl with gigantic wooden ends about 12 feet long by 5 feet broad, which takes the place of the "hammer" of the pole-trawl described by the Commissioners of 1863,* and which are simply the much enlarged wooden ends in use in the otter-trawls in the Forth in 1858. These huge wooden (door-like) ends have on one side in front two powerful iron bars meeting to form a V, and supported by two accessory stays, the whole forming a projecting apparatus to which the chain connected with the warp is fixed. Towards the rear a perforated iron plate gives passage to two chains (one from each of the powerful iron bars above mentioned) for the attachment of the swivel for the trawl-net. The lower edge of the wooden end is weighted anteriorly with a heavy bar of iron, which occupies nearly half the length of the apparatus. A special and powerful rectangular frame of wood, with a top snatch-block, is fixed at the port-bow and taffrail for hoisting the ends on board; and they form a striking feature from a distance, as—with the boards—they project 6 or 7 feet above the bulwarks. The foregoing trawl is said to capture cod more freely than the beam-trawl, as many as 20 score having been secured in April. It is, however, still on its trial, having only been introduced about six months ago.

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[*] The presence of a water-closet opposite, in one instance, appears to be objectionable.

It was formerly pointed out that, when the iron trawl-head was dislodged, great difficulty was experienced in repairing it—especially in rough weather. The new trawls at Aberdeen have a broad band of iron, which bends round the end of the beam, and on which the loop of the trawl-head goes. It is secured by an iron pin and safe. This sheath protects the end of the beam, and must save much time at sea. At Granton the ends of the trawls are guarded by flat iron plates, but they do not form a loop over the ends. The trawl-heads are secured by a pin, as already mentioned. In the finest ships the length of the trawl-net is about 118 feet, and the arrangement is as follows:—For the first 56 feet next the beam the mesh of the net is 3 inches from knot to knot; the next 38 feet has at first a 2½-inch mesh, diminishing to 2 inches towards the posterior end, while for 24 feet the bag or "cod"-end of the trawl-net has 1½-inch mesh. At Montrose the trawl-net consists of 44 feet of 3-inch mesh next the beam, then 44 feet ranging from 2½ inches downwards, while the last 14 feet has 1½-inch mesh. There is thus no diminution of the mesh at the "cod"-end. Moreover, no improvement in the shape of a "bonnet" or apparatus for preventing the compression of the fishes has been found serviceable. The net has various rubbing pieces of old net and "bass" ropes, and the usual pockets internally. The ground-rope is variable in composition. The majority have this part of the trawl composed of rope only—an outer layer being wound round a central rope. The ground-rope of the Montrose ships is of Manilla soaked in tar, 8 inches in circumference, and made up to 13 with others twisted round; and in the finest ships elsewhere it is 124 feet long. In some, two pieces of chain are inserted at the ends, thus making three divisions of the ground-rope, viz. a central, entirely of rope, and two lateral, with a centre of 18 feet of chain, each being tied to the other with spun-yarn. Ground-ropes with chain throughout are not now used. In certain ships the ground-rope has a centre of wire-rope with a series of wooden rollers, with occasionally here and there a pair of metal rollers (12 in all—Gunn's patent). The rope is also in three divisions, and costs about £6 10*s*., or 30*s*. more than the ordinary form composed only of Manilla ropes. This arrangement is thought at Aberdeen to give an increased catch of fishes—sometimes about 5 or 6 baskets more than by the ordinary ground-rope. In some ships, again, the port and starboard-trawls have each a different ground-rope; in the one the rope is all of one piece, whereas in the other three breaks occur, viz. two of wire and one of chain. In one ship the ground-rope had only 8 feet of chain at each end, while the centre had rope. All, however, do not think that the rollers are so satisfactory as a ground-rope with pieces of lead in the centre. Moreover, one of the features which contrasts strongly with the condition in 1884 is the fact that the newest ships, with the exception of the Montrose vessels, now carry two trawls—a starboard and port-trawl—complete in all respects. This arrangement has been in force for at least four or five years, and probably was introduced from England. At Aberdeen, however, the second trawl is, as a rule, used as a reserve apparatus, and is not put into requisition until the first has received damage. The mode of working the two trawls would thus appear to differ materially in the respective countries, since, according to an interesting paper by Mr. W. L. Calderwood,* as soon as the contents of the first trawl are placed on the deck, the second is immediately "shot" overboard. The same arrangement has been found at Grimsby by Mr. Holt, who mentions, however, that the reserve-trawl is shot while the "cod"-end with its fishes is still hanging from the tackle.

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* Report, Sea Fisheries of the United Kingdom, vol. i, Appendix, p. 3.

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* *British Sea Fisheries and Fishing Areas*, Scottish Geogr. Mag., Feb. 1894, p. 73.

The General Steam Company's ships at Granton (nine in number) have not varied in regard to the single trawl-beam, but they carry a second net. Consequently the large snatch-block and rollers occur on the port-side only. As before, the net is attached to the trawl-beam by grummet-lashings or by cord. The other parts, comprising the dandy and bridles (each about 25 fathoms) and the chain for the former do not differ materially from previous descriptions. The steel-wire rope is about the same length, viz. 200 to 240 fathoms, and lasts about ten months. The aluminium trawl-warp does not seem to have met with favour in Scotland. In some ships it is not, as formerly, left on deck after the check of wire-rope is fixed to the mizzen-mast, but carried outside the bulwarks, so as to avoid accident to the men. Those which, like the Montrose ships, use a Manilla rope (generally about 180 fathoms), require a new one every six months, the old one being utilised in preparing ground-ropes.

The shooting of the trawl is carried out in a similar manner to that of 1884, only there are no trawl-davits at the taffrail in the best Aberdeen ships; and, instead of the snatch-block then in general use, more convenient "dandy" scores (snatch or tumbling blocks), of which Sudron's or Scisson's patent are the best. At Granton and Montrose the trawl-davits are still in use, with snatch-blocks on deck. The lid of the block is opened during trawling. The trawl-warp leaves the drum, passes round a capstan, and out through rollers, either on the port or starboard-side, according to the trawl in use. Blocks on the mizzen-mast are still employed to hoist the stern-end of the trawl, and the foremast has a derrick. In "shooting" the trawl the ship goes at full speed. When the "cod"-end of the trawl is unshipped, the mate at the same time orders the fore-trawl-beam lashings to be freed, and when the beam is at right angles to the ship the "stopper"-rope is let go, and the order "ware forward" then sends off the trawl-warp from the drum.

A better arrangement now exists for assisting in unshipping the heavy trawl-heads, for these rest on a stout wooden platform about 18 inches high, and thus are easily swung over the rail; and, besides, the deck is saved from injury. In one or two ships at Granton larger platforms for the fore-end of the trawl have been fitted. In a new vessel, indeed, a square of plate-iron has been put on the deck at the point most injured by the trawl-head. In rough weather a chain fastens the trawl-head to the nearest iron stanchion at the bulwarks, and is used in bringing the front trawl-head on board. In the same way an additional chain at the stern-end is sometimes useful. In the Montrose paddle-ships the wheels for winding the trawl-warp (a Manilla rope) are below, and only the capstan is on deck. The latter (capstan) in some trawlers is made too high, and is wrenched out of its fastenings.

The trawl is usually down for five hours on the "Great Fisher Bank" and other grounds, though trawlers working near home regulate the time rather by the nature of the bottom than anything else, in some cases spending as much time (three hours) in mending the net as in trawling on hard ground, or where wrecks and anchors occur. The trawling period, indeed, on hard ground is about three hours, on soft ground five hours. When productive ground is discovered, a "dan," or buoy, with a red or black flag by day, and a white globe-light, close to the surface, at night, is put in the water to mark the spot, though it is liable to be carried away by other ships, and the lamp broken. This buoy has a pole, with heavy iron bars, at one end, and towards the other about ten flat pieces of cork, upwards of a foot square. In one or two ships floats of skin—such as the liners use in herring-fishing, with pole and flag, were substituted for the cork buoys, or small pieces of cork on a string. The rate of speed when trawling is, as formerly, about 2½ knots an hour, though on muddy ground a higher rate is sometimes maintained. In sailing, the best ships go about 11 knots. At night the captain and mate take watch alternately with one of the crew.

The crews on board the trawling ships remain very much as in 1884, the usual number being eight, though there are only seven in the Montrose paddle-ships, one of whom is cook. The latter may be either an old man or an adolescent. Each is furnished in the newest ships with a life-jacket of cork, and there are besides two life-buoys on deck. Only two at Aberdeen, the captain and mate, now have a percentage on the amount of fishes captured. The rest of the crew have ordinary wages. At Montrose the captain and two fishermen have a share in the "catch;" the rest have wages. There are seven men on board the ships of the General Steam Fishing Company at Granton, instead of eight as formerly. The percentages given to each remain almost as in 1884, a graduated series running from the "deck-hands" to the captain. The first engineer gets 5*s.*, and the second 3*s.* 4*d.* per ton of fishes.

In 1884 the Granton General Fishing Company's ships used "cringles" in transferring, during stormy weather, the fish-boxes to the "carrier" for the day. This practice has now been abandoned, and the ships either run to quiet water, and place the boxes on the deck of the "carrier," or they are at once transferred by boarding. It is during the latter operation that considerable injuries occur to the bulwarks and rail of the ships, the former having the stays bent, and the latter being frequently driven in.

One of the newest ships* at Aberdeen is a steel vessel—with a well—for fishing at Iceland and Faröe. It is 103 feet between the perpendiculars, and 114 feet on deck, 21 feet broad, and 12½ deep. The well is one of Houston and Mackie's patent fish-wells, and occupies the entire centre of the ship, the roof of the well sloping inward about half-way up the side of the ship, and leading to the hatches—the opening thus being much smaller than the bottom. The water accordingly will be somewhat steadied during the motion of the ship, though, as the cod will have a roof to rub against as well as walls, injuries may readily occur. The water is driven in during the voyage, rises to the surface of the well, and overflows by an opening in the side of the ship. A constant current is thus kept up. A grating at one end (the lower) permits the removal of refuse from the bottom of the well. While the cod swim freely in the tank, the halibut are tied, as usual, by the tail to the iron rail at the margin. The vessel has been specially fitted for the capture of these by hook and line; and at present no trawl is aboard, though such can be shipped at any time, and the newest apparatus (*e. g.* steam-winch and Sudron's patent dandy-score) is in readiness. The foremast has a derrick-boom, and the anchor-winch is worked by steam. The boat rests on a swivel-stock on the port bow, and is intended to be used as an accessory well. The cabins for the crew (viz. captain, two engineers, and nine men) are at the stern, while in the high bow is a store, and behind a convenient hold for fixing on the bait (herring). An ice-house, fish-hold, and all the newest fittings in the engine-room and other parts show the care that has been bestowed on the construction of the vessel. The consumption of coal is estimated at 3 tons daily.

Similar ships to the foregoing have been employed for some years at Grimsby for line-fishing in Iceland, but several improvements have been introduced in the new ship. Moreover, it can also be used as a trawler when required.

III. THE PRESENT STATE OF THE BEAM-TRAWL FISHERY IN RELATION TO THE FISHING-GROUNDS AND THE FISHES.

In 1884, under the head of "General Remarks," a careful survey of the situation of the fisheries in connection with both line-fishing and trawl-fishing was drawn up.† In reading over these remarks at the present time the position does not seem to have been misunderstood; indeed, there is little at variance with the condition as now shown by ten years' experiments and observations. Amongst other remarks it is stated that "steam-trawlers at present can only fish profitably within a moderate distance of the land; and were the fishes to become so thinned that, with all the skill and energy shown in managing the ships, the returns proved unsatisfactory, trawling might voluntarily disappear. There is no reliable evidence, however, that before such a result would happen irreparable injury would have been done to the sea-fisheries."

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* "Ocean Bride"—Mr. Drummond's.

† Vide Report of the Commissioners, pp. 377–380.

Now, at that time there were in Scotland a total of 61* trawling-vessels—of which probably about one-half were steamers, the other half being sailing boats or vessels used for trawling. The exact numbers cannot be obtained, but there were from 12 to 20 boats used in trawling at St. Andrew's, 6 to 8 came from Broughty Ferry, 2 or 3 each from St. Monan's and Cellardyke, and others existed in the Moray Firth. Trawling, indeed, at St. Andrew's was an old custom, the Buckhaven fishermen having introduced it early in the century, and subsequently the local fishermen carried it on more or less regularly, generally trawling in September and October, and in March and April, though occasionally much longer. The frequent presence, however, just before the period of the Trawling Commission, of 10 or 12 powerful steam-trawlers to compete with them on their own ground quite altered the aspect of affairs. The energy with which the steam-trawlers generally worked—for trawling went on by night as well as by day, and in weather unsuitable for the liners—introduced in Scotland a new era into the department. Fishing was to be carried out no longer by more or less independent crews, bound together by blood-relationship or other ties, and whose working hours were largely regulated by the weather and tides, or their own convenience and necessities. Moreover, their whole domestic life was interwoven with the time-honoured pursuit. Their wives and daughters laboriously baited the hooks and arranged the lines in the baskets for "shooting," they gathered the "bent" grass for separating the layers of the line, and with the sons dug lob-worms or procured mussels for bait. In the olden time, indeed, their wives and daughters were likewise their fish-merchants, and disposed of their captures to the best advantage. Now (1883) active and powerful vessels, propelled by steam, and thus more or less independent of the weather—manned by a captain responsible to owners or their manager, a crew bound together only by discipline and pay, and whose fishing apparatus required no bait, appeared on the field. Further, instead of following the pursuit on grounds familiar to generations before them, the new fishermen not only ranged over these, but sought new and sometimes more distant fields. Capitalists took up the question, and fitted out powerful ships in both Scotland and England, and sent them into Scottish waters, so that the liners met with most formidable rivals. The complaints of the line-fishermen at this period (1883) and subsequently necessarily attracted much attention, and great sympathy has always been expressed in regard to their condition, for undoubtedly the larger and more regular supply of fishes had a tendency to diminish prices, and this caused a reduction of income to the liner, and the fishes on certain of the nearer grounds were thinned, and perhaps rendered more wary. In the Report of 1884 it was said that "two competitors are in the field instead of one, and for the liner it may take closer work, even with all the help improved modern appliances in boats and material can give, to keep pace with his rival;" and, further, that it would be a great calamity if any mishap should befall such a fine race of men—hardy, willing, and adventurous. Complete destruction, or, at any rate, most serious interference with the fishing-grounds, and the destitution of the fishing population, was then predicted, and many anxious eyes watched the development of events, since about 45,000 men at least were dependent on the net-and-line-boats of the country, whereas only a few hundred—perhaps between 200 and 300—were at that time engaged in the trawling industry.

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* The numbers are taken from the Report of the Select Committee of the House of Commons, 1893, p. 396.

Since 1884 the trawling vessels have steadily increased in number, so that within the ten years they have been considerably more than doubled, the returns for 1893 showing that there are no less than 142 vessels and 720 men thus employed,—the total value of vessels, exclusive of gear, being about £240,737. Or, to go more minutely into details, of this number 72 are steam-trawlers, having a tonnage of 2,625 tons, and valued at £237,004, to which has to be added the fishing gear, £10,746—making a total of £247,750. These vessels are manned by 544 men. The rest (70) are sailing trawlers, having a tonnage of 423, and valued at £3,733, while their gear is estimated at £1,332—making a total of £5,065, with 176 men on board.

In addition to the foregoing there were 39 steam-trawlers belonging to English owners, fishing regularly from Scottish ports, and the tonnage of which was 959 tons, valued £92,100, and value of gear £3,850—making a total of £95,950. These had 296 men on board. The disproportion between the number of men employed and the cost of the material is chiefly brought out when it is mentioned that for 1892 the liners and net-fishermen were 45,629, while they had 13,865 boats, valued at £680,000. It will thus be seen that, while the average is about £1,695 for each trawling ship, for the liner it is about £49. The disproportion, again, in the trawling vessels, between the first-class and the small sailing-boat, *e. g.* of the Clyde, is very great, the former being about £5,000, the latter under £40.

If the returns of round, flat, and other fishes landed, irrespective of herrings, sprats, sparlings, and mackerel, which do not prominently bear on the present question, be considered, it is found that in 1892* the liners brought to shore 1,229,809 cwts. of round fishes, viz. cod, ling, torsk, saithe, whiting, haddock, and conger, which realised, at 8*s.* per cwt., £516,524; the trawlers landed 261,200 cwts. at 10*s.* 11*d.*, or £143,062; the liners produced 100,228 cwts. of flat-fishes, viz. flounders, plaice, brill, skate, halibut, lemon-dabs, and turbot, at 10*s.* 9*d.*=£53,973; the trawlers, 77,649 cwts. of flat-fishes at 25*s.* 4*d.*=£98,295; while of other kinds of fishes, which include hake, bream, gurnard, cat-fishes, and sillock, the liners had 61,224 cwts. at 4*s.* 9*d.*=£14,646; and the trawlers, 41,256 cwts. at 4*s.* 7*d.*=£9,410. The total in each case are, for the liners 1,391,261 cwts. and £585,143; for the trawlers 380,105 cwts. and £250,767.

In glancing at the returns (1892) of the board, which were handed in by the Chairman to the Select Committee last year, it would seem that one fish, viz. the green cod or coal-fish, is included both amongst the round-fishes and the "other kinds of fish," in the former having the name of "saithe" (adult), and in the latter "sillocks" (young); but this is not a point of much importance in regard to the results. As might be expected, the liners, and notably the long-liners, have the predominance in the round-fishes, especially in regard to cod, ling, and conger, the latter being apparently seldom caught in a trawl on the Eastern coast. These large fishes, moreover, would appear to protect themselves to a considerable extent from this apparatus, especially when it is in frequent use, so that it is only in water that is disturbed by gales or by working at night that they are caught in numbers under these circumstances. Nor is this surprising, since even a tiny cod, of little more than one-eighth of an inch, can avoid the forceps intended to capture it. The cod and saithe are also largely caught by gill-nets on the West coast; while the great lines, with hooks baited with herring, are the chief means of capture used in the case of the conger. Further, it has to be remembered that the trawlers, both near and distant, as a rule, throw overboard their small haddocks (8 to 9 and 10 inches), in both cases because it is not worth their trouble to bring them to market and pay dues for the trifling sum obtained for them; and in the instance of the distant trawler, to avoid, in addition, the labour of "gutting" and the expense of ice. Yet the liners bring these to market and they are included in their returns. It is an interesting fact that, notwithstanding the recent remarks concerning the condition of the trawled fishes, that the price of the latter surpasses that of the former by 2*s.* 11*d.* per cwt. It is true the trawler can more readily reach the market with his fishes, but against this has to be placed the great number of local fishing-boats which have only brief distances to traverse, and the fact that the trawlers who go to distant banks bring fishes "gutted" as well as preserved in ice, and the appearance of which is not always in their favour.

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* The full value of the labours of the Royal Commission of 1883, and especially of the late Lord Dalhousie, in establishing a series of proper statistics for the fisheries of Scotland, cannot be over-estimated.

When the flat-fishes are considered, it is found that though the liners produced considerably more in weight, yet the price obtained per cwt. is not half (by 3*s.* 10*d.* less) that got by the trawlers, so that the total value of the flat-fishes procured by the latter is nearly double that of the former.* Yet we know that halibut are largely caught by the liners, and that the three-mile limit and the closed waters in addition are at the disposal of the latter for relays of lines wherewith to capture plaice, dabs, and flounders. In all probability, however, it is the plaice, the witches, and especially the lemon-dabs and the turbot which prove so advantageous to the trawlers.

Of the "other kinds of fish" little need be said except that comparatively few hake come into the trawl, whereas the liner perhaps obtains a larger number; that while the liner brings the gurnards to shore and often eats them, they are frequently thrown overboard by the trawler; and that the cat-fish (wolf-fish) is caught by both in considerable numbers, but whereas, in certain trawlers, this fish is taken to port on the Tuesdays, it is thrown overboard at the end of the week.

In 1893 the equivalent returns show that the liners brought to land 1,136,389 cwts. of round-fishes = £466,399, this being 93,419 cwts. and £50,125 less than last year. The most marked deficiency has been in haddocks, 69,766 cwts. and £35,092; cod, 54,260 cwts. and £20,661; and whiting, 15,381 and £5,741. An increase had taken place both in line- and trawl-fishing in the other round fishes, viz. ling, torsk, saithe, and in the conger caught by line. How far this diminution was due to the unfavourable weather of 1893 is an open question. It certainly must have had some influence. The abundance of very small haddocks is another fact to be remembered, since many were not brought to shore, and they occupied hooks on which larger fishes might have been caught. The trawlers landed 309,862 cwts. of round fishes = £178,304, or 48,662 cwts. = £35,242 more than last year. With regard to flat-fishes, the liners produced 57,149 cwts. = £43,306, or 4,685 cwts. and £48 more than last year; the greatest increase, 5,594 cwts. and £566, having been in halibut, but these apparently were largely caught in distant waters, such as off the coast of Norway, Iceland, Faröe, and elsewhere, so that they confuse the returns from British waters. An increase also exists in soles (lemon-dabs?) of 50 cwts. and £120. A slight decrease, again, occurs in flounders, plaice, and brill. The trawlers landed of flat-fishes 71,024 cwts.=£89,781, a decrease of 604 cwts. and £7,243 on last year, this decrease being largely due to the deficiency of lemon-dabs, viz. 6,133 cwts. and £8,448, and a deficiency in turbot of 94 cwts. and £762, while an increase occurred in halibut and a larger increase in flounders, plaice, and brill, 5,197 cwts. and £1,597. This year skate form a separate return, which shows that the liners produced 52,626 cwts. and £10,725, or 4,862 cwts. more than in 1892, yet with only a trifling excess of income over that year, viz. £9 10*s.*—a result probably due to diminished prices. The trawlers landed 5,383 cwts.=£1,015, or 637 cwts. and £253 less than in 1892. Of "other kinds of fishes" the net fishermen brought 3,517 cwts.=£891, or 102 cwts. and £731 more than in 1892, while the liners landed 46,461 cwts.=£10,726, or 11,347 cwts. and £3,160 less than in 1892. The trawlers again caught 39,418 cwts.=£9,215, or 1,838 cwts. and £195 less than in 1892.

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* At Montrose, for instance, the flat-fishes landed by trawlers realised nearly 20*s.* per cwt., while those caught by line produced only 9*s.* 11*d.* per cwt. But turbot alone was sold at £3 6*s.* 2*d.* per cwt., so that the trawlers had the advantage in this respect.

The price of the round fishes in 1893 is respectively for the liner 8*s.* 2½*d.* per cwt., and the trawler 11*s.* 6*d.*, or a balance of 3*s.* 3½*d.* in favour of the latter, and therefore a higher proportion than in 1892. In regard to flat-fishes the inclusion of skate makes a considerable difference; thus the average price for flat-fishes, inclusive of skate, is for the liner 9*s.* 10*d.*, for the trawler 23*s.* 9*d.* per cwt., whereas, when the skate are excluded, it is for the liner 15*s.* 2*d.*, for the trawler 25*s.* 3*d.* In the former case the trawler receives no less than 4*s.* 1*d.*, more than double the amount obtained by the liner; in the latter case the trawler receives 10*s.* 1*d.* per cwt. more than the liner. The disproportion in any case is marked. In connection with prices, however, it has to be borne in mind that in many cases the liner is compelled to sell his fishes in remote districts or unfavourable markets, whereas the trawler takes care to put his fishes into the best market, and in quantity.

Again, the grand total of all kinds of fishes landed in 1892 was 5,436,138 cwts. If herrings, sprats, sparlings, and mackerel (viz. 3,664,771) are deducted, 1,771,367 cwts. are left, of which 1,391,262 cwts. were caught by liners, and 380,105 cwts. by trawlers, or, in other words, the liners caught more than three times the quantity of fishes landed by the trawlers. In 1893 the grand total of all kinds of fishes notably exceeds that of 1892, and is no less than

6,208,018 cwts., or 771,880 cwts. more than in 1892. The greater proportion of this, however, is made up of herrings, viz. 4,486,187 cwts.,—that is to say, a fish which is more or less unprotected at all stages of its life is apparently able to hold its own against its destroyers. It is, however, a purely pelagic form, and depends on the pelagic or floating fauna for its food. If the herrings, &c., are deducted a balance of 1,721,831, cwts. is left for the liners and trawlers, being 49,536 cwts. less than in 1892. Of this 1,296,144 cwts. were the produce of the liners (less by 95,118 cwts. than in 1892), and 425,687 cwts. the quantity landed by trawlers (45,582 cwts. more than in 1892). While the liners, therefore, showed a marked diminution in their total, the trawlers showed a considerable increase.

When the returns, however, of the fishing-boats of all kinds (other than beam-trawlers) are considered, it is found that there were in 1893, 363 fewer boats and vessels than in 1892, and a decrease of 1,689 fishermen and boys. This condition of things is sufficient to account for a considerable diminution of line-caught fishes, without regarding the unfavourable weather of the season. Moreover, it has to be remembered that fishery statistics are far from being complete, for though the returns show that the quantity of fishes mentioned has certainly been landed, they do not indicate those fishes which have been landed and not reported. On the other hand, the number of the trawlers has increased by two (probably powerful steam-vessels) and eighteen men during the year.

In 1884 trawling was carried on within a "reasonable distance" of land, so that the paddle-ship could deliver the catches of the night in time for the market next morning, or the daily "carrier" of the fleet of steam-trawlers from Granton, by leaving the fishing-grounds in the afternoon or evening with the united catch, could reach that port early next morning. The vessels from the Moray Firth could land their fresh fishes at Macduff or Aberdeen, and the vessels from Montrose and Dundee carried fresh fishes to those towns.

For ten years the trawl-fishery has been prosecuted with vigour, and it is interesting now to see what areas the ships frequent, and with what results. To commence with the most northerly, viz. Aberdeen, at which trawling has made great progress since the former date (1884), it is found that, whereas the chief supplies were brought fresh from the adjoining sea by the older paddle-ships, or from the Moray Firth by the more powerful vessels, the main supply of the present day comes from the "Great Fisher Bank" or from Iceland. Instead of the activity displayed in 1884 in the strip of sea from 10 to 20 miles off the coast, between

Aberdeen and Montrose, only a few vessels are now seen at work here and there in good weather. Fishes are by no means absent from this area, and at certain times occur in considerable abundance, but the individual catches at other times are limited; and on the rough ground 10 or 11 miles off, in 33 fathoms, it sometimes happens that, after three hours' trawling, about the same time has to be spent in mending the net. Yet lemon-dabs and sail-flukes or "megrims" (*Arnoglossus megastoma*) in the deeper and softer parts, with the larger haddocks and other forms, render the work there still worthy of attention. If small haddocks brought fair prices, the work would, indeed, be tolerably remunerative, as they are at present in very great numbers. The liners work on the same ground and catch chiefly the latter fishes. There is no indication that fish-food has been seriously interfered with on this ground, but, on the contrary, invertebrate life of all kinds is in great abundance. Moreover, the enormous numbers of pelagic sand-eels, from 15 to 33 mm. in length, intermingled with swarms of young flat-fishes, on these grounds, and on which many of the fishes were feeding in May, is a feature of moment. In 1884 the captures on the northern part of this area during the summer months were comparatively limited, and it was only the advent of the herring in autumn that caused a notable increase of white fishes. To-day, at the distance from land just mentioned, each haul in daylight produces from a basket to a basket and a half of lemon-dabs, about three-fourths of a basket of large haddocks, and 4 to 5 boxes of small haddocks. At night, a few ling, cat-fishes, and cod are added to the catch. Few whiting are procured, and the same feature was occasionally seen in 1884, for the whiting are often in the upper parts of the water. Very few cuttle-fishes occurred in May. The "catch" just mentioned is not a heavy one, and is probably surpassed by other ships, but it at any rate shows that fishes are still present in considerable numbers. This is further demonstrated by examining the "catch" of a liner with six men on board, and which had been at sea about 32 hours, fishing on the 28th and 29th of May, probably from 28 to 30 miles off Aberdeen, viz. 9 boxes of large haddocks, the largest fish reaching the length of 20 inches, the rest smaller (at 24*s.* per box), $3\frac{1}{2}$ boxes of small haddocks, a few cod, dabs, one lemon-dab, and a few whiting—making a total of about £12 for the six men. In the same market lately the large haddocks brought 29*s.* per box, so that the above is probably not an unusual price.

At the southern end of the ground just mentioned, viz. off Montrose, a trawler working, three years ago, about 25 miles off, in August, landed the very high catch of 500 boxes of haddocks in a single night. At present the takes range, per week, from 100 to 140 boxes of haddocks and flat-fishes, besides cod, coal-fishes, and gurnards. Plaice are said to be rather scarce, even lemon-dabs being more abundant. For the night of the 29th May 18 boxes of haddocks and flat-fish were landed, besides cod and ling. For each box of good haddocks (7 stones) 16*s.* were obtained—a much lower price than in Aberdeen, where, however, the box was heavier (8 stones or more). The "catch" for the night was about a ton in all. A small liner, with five men on board, which went out between 9 and 10 A.M. on the 29th, landed at 5 P.M. (*i.e.* in 8 hours) ¾ box of large, ½ box of medium, 2 boxes of small haddocks, many about 9 inches long; 1 lemon-dab, 2 very fine cod, and 4 codling, and this though their lines were "shot" in broad daylight. The fishing-ground was from 8 to 10 miles off. This is a small "catch," but the circumstances under which it was made were not favourable. There can be no doubt that the entire Eastern coast abounded with multitudes of small haddocks, and that these have been captured in immense numbers by both liners and trawlers.

The best trawling ships, which are about 30 in number, at Aberdeen at present chiefly frequent the Great Fisher Bank, about 200 miles off, and from 30 to 40 fathoms in depth, it being a general opinion amongst fishermen that this, and up to 60 fathoms, is the most favourable depth for their pursuit, for they think that in deep water (100 to 175 fathoms) they get only conger, halibut, and skate; and elsewhere, as off the coast of Portugal, only sharks are procured at 500 fathoms. Yet the Rev. W. S. Green, off the west coast of Ireland, got "witches," ling, haddocks, and conger at 170 fathoms, and skate and forkbeard at 500 fathoms. On this ground (Great Fisher Bank), which is about 120 miles from east to west, and from 60 to 80 miles from north to south (a larger area than the enclosed region of the Moray Firth), the "catches" of these trawlers vary from 80 to 180 boxes or more, consisting of plaice, haddocks, turbot, and other fishes, which are procured in from 8 to 13 days, including the time spent on the voyage. Since the Moray Firth was closed, these ships, therefore, find it remunerative to undertake this long journey, and bring their fishes preserved in ice to the market in Aberdeen. They do not seem, however, to find it so profitable to fish in the waters near the Scottish shore. In the same way, the powerful ships which proceed to Iceland bring from 200 to 400 boxes of fishes in about 14 days. The plaice procured in this region are recognised by the dark spots; and as these, the haddocks, cod, and other forms have been "gutted" and preserved in ice, they do not have so attractive an appearance as those caught by the liners.

Besides the areas just mentioned, some trawlers proceed to Blacksod Bay, off County Mayo, on the West coast of Ireland, for soles and turbot, while in February and March others go to ground 20 to 40 miles off Scarborough, where, perhaps, 20 score of cod are caught in a night. Some, again, work on the turbot-ground, from 80 to 90 miles off Aberdeen, and others find on the Dogger Bank catches of from 18 to 20 boxes of plaice.

When the trawlers from Granton and Leith are considered, it is found that, notwithstanding the closure of the Forth (for 3 miles beyond the Island of May), these ships have increased in number, have been improved in equipment, and have been able to overcome the difficulties with which they were handicapped—in comparison with the liners. In the case of the General Steam Fishing Company's ships, and probably in others, however, very definite instructions—based on carefully-recorded data, compiled during the last twelve years—are issued to each captain as to the distance to be traversed (by the log), and the direction on every occasion. No haphazard selection of fishing-grounds is made. Thus in December, besides the ordinary fishes, numerous cuttle-fishes (so valuable for bait) are procured off the Isle of May. In January, February, March, and April they work from 5 to 10 miles S.E. of the Isle of May, viz. more or less on the grounds frequented in 1884. In March and April the cod are captured, as before, in considerable numbers as they congregate during the spawning season, and in the earlier months as they follow the herrings. In June, July, August, September, October, and November they take to the more distant grounds off the Forth—about 40 miles E. by N.E.

The opinions somewhat freely expressed by some in 1884 as to the decline of the trawling industry in the Forth and the adjoining area—notwithstanding all the advantages of a free area from inshore to offshore then possessed—do not seem to have been borne out by further experience. Even with the entire area of the Forth and St. Andrew's Bay closed, these vessels, now considerably increased in numbers, have found fishing profitable on the more distant grounds. They work on a certain area, either by means of a flag-buoy or otherwise, and strictly in accordance with the instructions given from headquarters. If the captures are observed to be decreasing, either from the thinning of the fishes or their being scattered, they change ground, as, indeed, was very noticeable in 1884, returning after an interval to the same area, to find that an increase has taken place. In connection with this filling up of areas over which trawling has been assiduously carried on, it is an interesting fact that the local boats—from 12 to 20 or more in number—found for many years that, on the whole, their best ground in St. Andrew's Bay was a line about 2 miles from shore ("Scooniehill," in a line with "the steeples"), and about 4 fathoms in depth. Boat after boat trawled along that line, wind and weather permitting, for four months of the year, and sometimes longer, and to the closing day it maintained its position as the best area for plaice. The same observation has been made at Brixham, where trawling has been in operation about a hundred years. It is quite evident, therefore, that other fishes took the place of those captured, and that this continued month after month and year after year. The whole question, therefore, in the larger areas outside the 3-mile limit is—Can the supplies from the neighbouring waters keep pace with the rate of capture now going on by both liners and trawlers? These supplies consist of the growth of the young from eggs on the area itself, and the immigration of eggs, young, and adults from other areas or the open water beyond. It is seen that, so far as human observation can go, the supplies of herrings are as plentiful as formerly, notwithstanding the absence of restriction and the great waste that annually takes place in this fishing. On the other hand, it is a matter of observation that the first hauls of the trawl on virgin ground are the most successful, and that by-and-by the catch diminishes, and the same occurs with the liners on their new "banks" or "reefs." Yet it cannot be said in either case that the fishes have been extirpated, but they probably have become more wary as well as diminished in numbers, and, moreover, they may have changed their ground, for fishes are constantly roaming. It has to be remembered that the food-fishes are not altogether confined to the shallower water in which they are usually followed, but they likewise extend into the deeper water beyond. Such deeper water and unfrequented regions, therefore, form reserves, in which the species is reproduced, the eggs, young, or adults passing into those areas in which the food-fishes have been more or less thinned.

The area last mentioned, viz. that off the Forth, is perhaps one of the most important in Scotland, in regard to the number and variety of its fishing-grounds. For the present purpose the area may be defined as that bounded by a line drawn eastward from Arbroath on the north, and a similar line from St. Abb's Head on the south. Between these points the Tay and the Forth pour considerable bodies of fresh water into the sea, while the Eden debouches into St. Andrew's Bay between them. The amount of microscopic food—both plant and animal—as well as of the smaller invertebrates which are carried to sea in this area, is very considerable, and in all probability is closely related with the richness of invertebrate life both in the waters and on the bottom. The enormous numbers of pelagic mussels swept from the Tay and the Eden alone form a remarkable feature. It is not surprising, therefore, that the fishing-grounds in this region still continue fairly prolific, notwithstanding the increased demands on their resources. In the same way the Moray Firth is another rich fishing-area on the East coast, though the rivers entering it are smaller.

The steam-liners and trawlers frequent the more distant grounds, not because the fishes are absent from the nearer grounds, but because their "catches," as a rule, far exceed in bulk those obtained on the latter. While, therefore, the present statistics show no serious diminution, it may be truly said that the total is kept up only by the supplies from Iceland, Faröe, and the Great Fisher Bank. But the nearer grounds would have produced a considerable supply if they had been perseveringly worked; and it cannot be doubted that they contained, at any rate, an immense number of small haddocks.* Moreover, these small haddocks had migrated from the distant waters, for it is a remarkable fact that, so far as ascertained, no great shoals of very small haddocks (*i. e.* less than 3 inches) have been encountered in inshore waters. The life-history of the haddock, indeed, between its post-larval condition and the adolescent stage of between 2 and 3 inches, is still comparatively unknown. Before the appearance of these hordes of small haddocks, it was generally asserted that the haddock had been more or less extirpated; hence the necessity for caution in dealing with such subjects. Again the question as to the completeness of the statistics of fishes caught round the Scottish shores has to be considered, and there are some who think much improvement is required in this direction. Indeed, the only satisfactory method would be for every liner, trawler, net-, crab-, or other fisherman to hand to the official on reaching the port a slip stating the amount and kind of the "catch," and the ground on which it was made, as indicated in the Trawling Report of 1884. Taking all these circumstances into consideration, therefore, there is no reason for despairing of the fisheries, especially when the enormous powers of reproduction of the round and flat-fishes, their transparent, floating eggs, and the vastness of the medium which encircles our shores are remembered.

The condition of the inshore waters (within the 3-mile limit) has elsewhere been dealt with,† and will again form the subject of future remarks. All that need be said at present is that, so far as can be ascertained, it would not appear that the closure of the inshore waters has made any marked increase in the fishes of the offshore waters, yet the younger fishes have now had time to pass outward and become mature; nor have the larger fishes been driven shorewards by the more frequent interference with the more distant areas. No change, however, could be expected if the scarcity were due to general over-fishing.

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* An idea of the numbers of these may be given by stating that a trawler brought on board, in two hauls, about ten tons of small haddocks, which were, however, freed. Many were probably killed.

† A Brief Sketch of the Scottish Fisheries, 1882–92, p. 6.

(*To be continued.*)

NOTES AND MEMORANDA.

Virgularia mirabilis.—The following letter has been received from Mr. W. P. Marshall:—I return you herewith the Eddystone specimen of *Virgularia mirabilis* that you lent to my late son and myself when we were at the Plymouth Biological Station, and am very sorry that the investigation we were engaged upon was not sufficiently worked out before his death for the report to be given upon this specimen.

The point under consideration was the development of the polyps in the early stages of growth of the colony, on which valuable information was given by this Eddystone specimen, which led us to a further examination of the younger specimens that had been obtained in the Oban dredging by the Birmingham Natural History Society.

The general result was as follows. In the *adult* specimens there are in the most matured portion—

8 polyps per leaf (or group).

7½ polyps per inch pitch of leaves (or 7½ leaves in each inch length of specimen).

In the Eddystone specimen there are—

3 polyps per leaf in the lower portion.
4 ,, ,, in greater portion of length.
16 ,, per inch pitch at the lower end.
10 ,, ,, ,, at the upper end.

And the appearance of the specimen suggests that it is at the stage when the fourth polyp begins forming.

In the Oban young specimens there are—

3 polyps per leaf throughout in 3 specimens.
4 ,, ,, ,, 4 specimens.

These correspond closely with the Eddystone specimen in the number of polyps per leaf, but there is a wide difference as regards the pitch of the leaves, namely (Oban specimens)—

56 to 96 pitch with 3 polyps per leaf.
64 to 75 ,, ,, 4 ,, ,,

The *adult Oban* specimens have a general pitch of about 48 at the lower end, and the pitch 16 at the lower end of the Eddystone young specimen is so exceptional as to suggest another species or variety.

The English Channel is not a recorded habitat for Virgularia so far as we know, except for this Eddystone specimen and a smaller fragment obtained off Falmouth in a former dredging excursion of the Birmingham Society in 1879.

Coryphella smaragdina.—On Friday, May 11th, a small Eolid was dredged near the Asia buoy. On subsequent examination it proved to be *Coryphella smaragdina,* A. & H. Alder and Hancock described the species from a single specimen found at Whitley, in Northumberland. It is also found in the Mediterranean. It is, therefore, curious that the species has hitherto never been found at Plymouth. The body of the specimen is about half an inch long and pure white in colour, the tentacles are equal in length, and the anterior angles of the foot are produced out into two tentacular-like processes. The branchiæ are disposed in five transverse bands, and are a vivid green in colour. Though the specimen has been nearly a fortnight in spirit the green is as bright as when the animal was alive. Alder and Hancock in their description of the species mention that they found it on the common *Fucus vesiculosus.* They go on to say that "this position was most likely accidental; at least, it must not be taken as a proof that this species is less carnivorous than its congeners." The Plymouth specimen was found crawling on a stone amongst a mass of Hydroids, so that Alder and Hancock's surmise is fully borne out.—J. C. Sumner.

AN EXAMINATION

OF THE

PRESENT STATE OF THE GRIMSBY TRAWL FISHERY,

WITH ESPECIAL REFERENCE TO

THE DESTRUCTION OF IMMATURE FISH.

BY

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By

Ernest W. L. Holt.

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Introductory.

It will be within the recollection not only of the comparatively small section of the community which is consciously interested in fishery matters, but of all those whom a sense of public duty or a lack of other occupation compels to some acquaintance with the current topics of the day, that the question of the deterioration of our sea fisheries commenced some few years back to assume something approaching to prominence. One of the earlier indications of the importance with which the question was invested, in the minds of those principally concerned, was the formation, in 1882, by a number of fish merchants, smack-owners, and others, of the National Sea Fisheries Protection Association,—a title which may well be forgiven for its length, in consideration of the happy augury it holds out of the enduring nature of the Association's services to one of our most deserving industries.

The Association endeavoured to ascertain not only the extent of the evil with which it had set itself to battle, but also the best means of holding it in check, by adopting the method of summoning annual conferences, to which were invited fish merchants, smack-owners, and fishermen from all parts of the coast, members of Parliament, and other guardians of the interests of the nation, and even representatives of such scientific bodies as endeavour to cultivate an acquaintance with matters marine. Subjects were selected for discussion and votes taken, which latter would perhaps have been more representative had not the power of voting been confined to members of the Association.

Every student of matters social is well aware that a Conference is usually prolific only to the third generation. It begets a Resolution, the offspring of which, adhering to the strictly discontinuous type of variation, is a Deputation. A deputation has been described as a "noun of multitude, which signifies many but does not signify much;" and the unanimity with which the sufficiency of this definition is accepted by those in office, of whatever shade of politics, is alone sufficient to prove that "great minds think alike."

It is not surprising that the conferences with which we are dealing achieved, for several years, only the usual result, or want of it, since it cannot be expected that any parliament will lightly undertake legislation when the bulk of its members only profess such acquaintance with its subject as for once is actually somewhat akin to that which they possess; while, strange as it may possibly appear to less enlightened nations, the principal kingdom in the Union has no department capable of dealing with the matter by minor methods, though in Scotland there is a Fishery Board, and in Ireland a Fishery Office, entrusted with very considerable powers within the limits of their respective countries.*

The conferences, however, cannot be said to have been wholly without result, since in 1893 a Parliamentary Committee was appointed to hear evidence and furnish a report. On this report the hopes or fears of those interested are at present centred, according to the light in which they regard the recommendations it contains.

So far my remarks have only, and in the briefest possible manner, dealt with the attempts made by the N. S. F. P. Association, as representative of the fish trade, to induce the Government to take steps to check the evil of which complaints were made, but other action was being taken in the meanwhile. The Marine Biological Association, although its activity is in the main directed to the prosecution of what would generally be termed strictly scientific pursuits, has always given prominence to the study of those organisms which are of importance to our fisheries. Thus, even before the Laboratory was completed, my colleague, Mr. Cunningham, had commenced his studies of the development and life-histories of the fishes which form the object of the fishing industry of Plymouth and the neighbouring coast—studies which have been continued without intermittence down to the present time. I allude only to those investigations which have a practical bearing such as appeals at once to the intelligence of every one, though it may be claimed with perfect truth that there is no item of marine biology that has not its economic importance directly or indirectly, in that due appreciation of the conditions of marine life without which no rational treatment of fishery questions can ever be attempted.

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* Somewhat similar powers are possessed by District Fisheries Committees of the County Councils in England, but each Council is independent of the others and, practically, of any central authority.

As may be supposed, the agitation in connection with the alleged deterioration of the fisheries came early under the notice of the Council. Complaints of the scarcity of fish, and of the injury inflicted by certain methods of fishing other than those used by plaintiffs, are matters of immemorial antiquity, but the present agitation was distinctly original in character. It had its origin, as usual, amongst those interested in one particular method of fishing, viz. trawling; but it differed from all other known fishery grievances in that the complaints of the trawlers, and of those who dealt in trawl-fish, were directed, not against some other body of fishermen, but against themselves.

The trawler, of course, has long been the recognised piscatorial scapegoat, reviled by the inshore line-fisherman with an energy which is usually in inverse ratio to that with which he pursues his own calling, and condemned with scant ceremony by the amateur "naturalist" and the public at large. But on this occasion, as I have said, the trawler was his own accuser, and it must be noted that the agitation originated with, and was practically confined to, the ports of Grimsby and Hull, the two greatest trawling centres of the North Sea, which is, of course, by far the most important trawling district. Other trawling communities, if aware that they were doing excessive damage, at all events did not consider that the remedy lay beyond their own powers.

An agitation conducted by one class against another obviously invites the suspicion that it is based chiefly on motives of self-interest, without any particular regard for the welfare of the community at large; but in a case like the present, though self-interest may reasonably be inferred to be the motive of inception, there would seem to be a much greater chance than usual that the object desired is for the general benefit as well as for that of the agitators.

Still, however strongly the genuine nature of an agitation may appear to be warranted by the probabilities of the case, common prudence demands that it should be supported by the most exact evidence of which the circumstances permit; and especially is this the case in fishery affairs, since experience has taught us that the ignorance of the fisherman of the most elementary features in the natural history of the organisms on which he depends, often leads him to set forth as fact, matter which is by no means capable of that denomination.

Moreover, granted that the complaints prove to be well founded, it will be conceded that remedial measures beneficial to the whole community have their best chance of origin in investigations conducted from a standpoint altogether independent of any trade interest whatsoever.

On these accounts it appeared to the Council of the Marine Biological Association that here was an investigation in which the means at the disposal of the Association could be most usefully employed, and no time was lost in instituting a series of inquiries as to the alleged destruction of immature fish by beam-trawling in the North Sea, and the best means of checking such destruction, if it should be found to exist on a serious scale.

These inquiries the Council was good enough to place in my charge, and for three years, according to my ability and opportunities, I have laboured to collect whatever information seemed to bear on the case. My headquarters were at Grimsby, where the Association, by arrangement with a local Society, secured a small laboratory, fitted with tanks and other conveniences, for my use. From time to time I have communicated the result of my inquiries, either in the form of articles in the Association's Journal, reports to the Council, or evidence before the Parliamentary Committee.

At the end of three years the object of the investigations may be said to have been accomplished, since sufficient evidence has been collected to allow us to form a fairly reliable opinion on the question, and the investigations have accordingly been closed so far as this particular matter is concerned.

Of course an important fishery like that of the North Sea will always afford abundant scope for the activity of the scientific inquirer, but no new question of paramount importance has as yet arisen, nor, indeed, is the old one by any means settled. Still we have at our disposal all the material necessary for dealing with it in a rational way, should such a proceeding ever commend itself to our legislators. I have indicated the various channels through which my information and views have already been communicated to the public; and, on closing the inquiries, I have been requested by the Council to draw up a brief epitome of the results arrived at, so that they may be presented to the public in a concrete form.

To do this is the object of the present paper, which is designed for a section of the public much more extensive than that which is in the habit of concerning itself with the literature of professional fishery. It is too much to hope that I may be able to invest my remarks with any interest not indissolubly connected with the subject itself, since facts are at best dry reading, and the habits of the scientific writer are not such as to pre-eminently qualify him for the lighter graces of popular penmanship.

A few words are necessary as to the arrangement of my material. The complaints of the trawlers and fish merchants resolved themselves into the following brief statement:—That large numbers of immature fish were destroyed by trawling, and that the supply of trawl-fish in the North Sea was in consequence diminishing. The fish especially referred to were flat-fish, the question of round-fish being considered of secondary importance. It was evident that, as to the diminution of the supply, I could not hope to obtain any absolute evidence of my own. Whatever information was deducible from the Board of Trade statistics was open to every one, and those statistics hardly went far enough back to be of much value, and were, and are, altogether insufficient in detail. I had, therefore, to depend, in forming an opinion, entirely on the reminiscences of fishermen, eked out in a few cases by the books of smack-owners. Any details of information under the last heading I am neither at liberty nor in the position to publish, and I must dismiss this branch of the inquiry with the assertion, whatever it may be worth, that I hold the opinion that there has been a considerable deterioration in the supply of the more valuable kinds of flat-fish. In the case of haddocks I am not convinced that the deterioration has been considerable. Such statistical work as I have carried on since I went to Grimsby will be referred to in due course.

With regard to the alleged destruction of immature fish, the first point to ascertain was the correct definition of the term immature; and then to find out where, and to what extent, the alleged destruction took place. This involved an examination of the different grounds, with the collection of all possible information as to their previous history.

Inseparably related to the whole question is the condition of the trawl-fishery as a whole, the methods by which it is conducted, and the conditions of the trawlers' life. Not only the deep-sea fisheries, but all minor industries which could in any way affect the question, demanded inquiry, and in the succeeding chapters I shall endeavour to deal with these several matters.

PART I.

CHAP. I.—THE NORTH SEA FISHERIES.

In addition to trawling, with which we are here almost exclusively concerned, the North Sea furnishes scope to a number of other branches of the fishing industry. Of these, line-fishing and drift-netting are the most important; oyster-dredging is a considerable deep-sea industry, and whelking may almost be included in the same category. The remaining branches, such as crabbing, lobster-potting, shrimping, and seining, are carried on in the more or less immediate neighbourhood of the coast. We are concerned with none of these except in so far as they may be shown to affect, or be affected by, trawling.

The North Sea fishery, if the apparent paradox may be pardoned, is by no means confined to the North Sea itself, since it is impossible to leave out of consideration the fishing operations of vessels belonging to, and regularly landing their fish at, North Sea ports. Many of these, chiefly liners, derive the bulk of their fish from grounds which lie altogether outside the limits of the North Sea. The Orkney, Shetland, and Faröe Islands, Rockall and Iceland, are all extensively worked by North Sea codmen, and the last-named district to some extent by trawlers also; the fish from these grounds pass through the North Sea markets, and are not discriminated in any Government returns from those caught in the North Sea.

A certain number of boats belonging to North Sea ports are engaged in fishing operations on the west coast of England and elsewhere, but, for the time being, they land their fish on the west coast, and so may be considered to cease to belong to the North Sea fishery. Drift-net boats—at least those which are worked the whole year round—may be said to be nomadic, making their headquarters in whatever district the fish may be at the different times of the year.

Fisheries of various kinds are carried on all along the east coast of Scotland, and these must of course be held to belong to the North Sea group. The bulk of the line-fishing, however, is done close to the ports to which the vessels belong; and even the trawlers, which are by law excluded not only from the territorial waters, but also from some grounds which can hardly be said to lie within the territorial limit at all, take very little part in fishing the grounds frequented by vessels from the east coast of England. An occasional Scotch steam-trawler may be found fishing the southern part of the North Sea, and landing her fish at an English port, but otherwise the industries of the two nations do not seem to commingle much. Consequently I do not think it would be profitable to enter here into a discussion of the Scotch trawl-fishery, even if I possessed any special qualification for the task.

The trawling industry of the east coast of England centres itself at various points along the coast, which are roughly divisible into a northern and southern group. The northern group comprises Grimsby and Hull, and several ports of minor importance, while Lowestoft and Yarmouth are the chief centres of the southern group. At certain seasons of the year, vessels from all ports may be found on the same grounds; but, speaking generally, those of the northern group are occupied on more northerly grounds than the rest.

The relative importance of the different trawling ports may be judged from the subjoined list of the numbers of boats owned and resorting to each. The figures, however, have at best only an approximate value, since of the total number of boats belonging to, say Grimsby, there is nothing to show how many may have been employed away from the North Sea, and for how long, during any one year. Again, in the number of boats resorting to a port, the statisticians of the Board of Trade (from whose returns this column has been taken), if they possess any information as to how often boats belonging to other places visited the port in question in the course of the year, do not take the public into their confidence. It appears to be the peculiar function of the Fisheries Department of the Board of Trade to formulate statistics which shall be just sufficiently complete to bring into strong relief the importance of what is omitted from them.

The preponderance of Grimsby as a fishing port is entirely independent of the drift-net fishery, since it sends not a single vessel to that industry. It rests almost entirely on the deep-sea trawl and line fisheries, although a certain number of its first-class vessels are engaged in deep-sea oyster dredging and whelking. Hull, though owning a less number of vessels than Yarmouth or Lowestoft, is only second to Grimsby in the trawl and line fisheries, since the whole of its fleet is devoted to these industries, and its large fleet of steam trawlers much more than compensates for its inferiority to southern ports in the number of its sailing trawlers.

The conditions under which the deep-sea trawl-fishery is carried

Table showing the number of first-class Trawling Vessels owned (i) *and engaged* (ii) *at the chief ports on the East Coast of England.*

	i.			ii.		
	Steam.	Sailing.	Total.	Steam.	Sailing.	Total.
NORTHERN GROUP:						
Grimsby	124*	460*	584	184	546	730
Hull	173	250	423	160	280	440
SOUTHERN GROUP:						
Yarmouth	11	456†	467	11	422	433
Lowestoft	0	300‡	300	0	320	320

Table showing the total number of first-class Fishing Vessels of all sorts owned at different ports on the East Coast of England.

	Steam.	Sailing.	Total.
Grimsby§	143	664	807
Hull	160	280	440
Boston	35	12	47
North Shields	88	0	88
Scarborough	16	71	87
Sunderland	10	0	10
Hartlepool	0	39	39
Yarmouth	11	498	509
Lowestoft	0	447	447
Ramsgate	0	159	159

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* Of these vessels, 4 steam "fleeters" and 82 smacks may really be eliminated, as belonging to a company which fleets all the year round, and lands its fish at London by steam cutters.

† Of this number 71 sometimes trawling, at other times drift-netting.

‡ Mr. B. M. Bradbeer (in litt., 19/2/95) remarks that there are between 30 and 40 Ramsgate trawlers which work from Lowestoft. Column ii (from Board of Trade Returns for 1893) is therefore too low for the present year.

§ The number of trawling vessels has already been specified; the balance is made up as follows:

(i) Steam codmen	20
(ii) Cod smacks	76
(iii) Oyster smacks	14
(iv) Whelkers	17

The crews carried by these vessels are—for (i) skipper, mate, four deck-men, three or four apprentices, two engineers, two coal-trimmers, and steward; for (ii) skipper, mate, two or three deck-men (three if there are less than four apprentices), and two to four apprentices; for (iii) six men, including skipper; for (iv) four men including skipper.

out at the different ports differ, so far as I can learn, chiefly in regard to the grounds affected, and in regard to certain market customs and requirements with which we are not here much concerned. My own knowledge of the deep-sea work is derived almost entirely from Grimsby, so that any remarks I have to make must be taken as applying to that port, unless special mention is made of another. I do not know of any particulars in which the Hull fishery differs from that of Grimsby; the boats seem to work precisely the same ground, and are of the same build and average tonnage. Much of the Scarborough trawling fleet is more or less constantly employed at Grimsby, and steamers from the more northern ports are at least frequent visitors.

The fine fleet of steamers owned in Boston appears to be engaged in the same operations as those from Grimsby and Hull. I cannot claim much special knowledge of the boats belonging to southern ports, but I believe that the necessarily scanty nature of the account which I give of them is of little importance, owing to the absolute preponderance of Grimsby and Hull in the North Sea trawl-fishery as a whole.

Besides the deep-sea fisheries, in which we may include trawling, lining, and drift-netting, and, at Grimsby, oyster-dredging and whelking, there are a certain number of men at most of the larger ports engaged in longshore work of one sort or another, such as shrimping, prawning, crabbing, seining, whelking, stake-netting, inshore line-fishing and trawling, &c. &c. With some of these we shall have to deal in a later chapter.

The regular prosecution of the deep-sea fisheries may be said to be confined to such large centres as our remarks have hitherto dealt with. Such centres have, no doubt, attained their present importance in virtue of physical conditions which have lent themselves to the development of the fishery on a large scale, but there exist, of course, a great number of smaller communities.

In fact, wherever the nature of the coast permits of the launching of a boat of any sort, there will be found a race of fishermen engaged in such operations as the harbour or beaching accommodation and the resources of the adjacent grounds permit.

But the conditions of these small communities are altogether different from those of the larger centres. Their importance, in fact, may be said to be purely local, and the share which they bear in the production of the general food-supply of the nation is so insignificant that the extinction of any one of them as a fishing community would hardly be felt outside the limits of the parish. It needs, however, no argument to demonstrate that their welfare is none the less important on this account; and I believe that for many years the recently constituted District Fisheries Committees will find the most profitable outlet for their legislative energy in safeguarding the true interests of these smaller communities, while they are fitting themselves for the much more difficult task of coping with the problems in connection with the greater fisheries.

Apart from the question of its production, a small fishing community differs essentially from the larger ones in what may be termed the social conditions of the industry. In many cases—in fact, in most—the men are fishermen by heredity, and every member of the family assists in the trade to the best of his or her ability. For generations the men have been fishermen, intermarrying almost entirely amongst families engaged in the same occupation, and it seems quite possible that it will be some time before those twin reformers, the board school and the penny novelette, will succeed in seducing any considerable proportion of the race to pursuits which may appear to offer greater profits at less outlay of work and hardihood. In these small communities there is hardly such a thing as specialisation in fishery; every man is acquainted with, and practises in due season, every mode of fishing which is possible to him, and frequently ekes out his subsistence by farming on a very small scale.

There are among them no fishing companies, not even smack-owners on a large scale, but each man either owns his own boat, or at least stands in a much more familiar relationship to the owner than is the case in the larger communities.

My own acquaintance with the small fishing centres is confined to those on the coast of Yorkshire, and among them we find represented almost all stages in the evolution of a modern fishery. Some appear to have retained unchanged the condition which must have been ancestral to that of nearly all the large stations. Others are perhaps in a state of transition. I include Scarborough among the larger centres, in virtue of the number of first-class vessels which are owned at, if not by any means constantly worked from, that port, but it presents certain peculiarities of interest. The development of the fishery, due to the introduction of trawling, has by no means swamped the inshore fisheries; while the limitations of the accommodation for large vessels, and the competition of other centres possessing better harbours and greater railway facilities, appear to have put a term to much further progress in the deep-sea industry. At the same time the protection afforded to the inshore men by the District Committee's regulations appears to be materially improving their welfare, and may tend to bring about something of a reversion to the more primitive condition.

The important part which the introduction of trawling has played in the modification of the fishing industry of communities which were originally devoted to longshore and drift-net pursuits, cannot be better illustrated than it is in an account which my friend Mr. T. N. T. Potts has given me of the Sunderland fishery during the period covered by his own memory. It is reproduced at length in a succeeding chapter (p. 367).

In the smaller fishing stations, where no sufficient harbour or beaching accommodation exists, it follows that there are no large fishing vessels. Such may be owned and manned by the men of a small station, but of necessity they frequent some port with a suitable harbour. The work is chiefly carried on in small open boats, cobles and whalers, which can be beached without much difficulty. The nature of the fishing varies with the time of year. In the spring and early summer the manipulation of crab-pots will occupy the bulk of the community; later in the year the herring make their appearance, and promptly receive due attention. For their capture either the small open boats are used, or larger decked boats which spend the rest of the year high and dry on the beach, or, at Whitby, far up the river.

The herring season (or in the south the crabbing season) over, recourse is had to line-fishing, chiefly for cod and haddock, and the question of bait at once becomes of importance. If a productive mussel-bed exists within a reasonable distance, cargoes are brought and re-sown by the larger vessels before the latter are laid up, and from time to time the supply is renewed,—by the cobles, if weather permits; if not, by rail. Where the coast is rocky, "flithers" (limpets) are collected, as required or available. Lugworms are highly prized, but are comparatively little used, as few are obtainable at any place where an inshore line-fishery is carried on, and their perishable nature has so far militated against their dispatch from the Humber estuary, where they swarm unmolested in countless thousands. On the sandy part of the Yorkshire coast south of Flamborough the chief bait supply appears to be whelks, obtained by "potting;" but other bait, such as squid, herring, and mussels, is imported.

It need hardly be remarked that the conditions, social and otherwise, under which the deep-sea fisheries are carried on from large ports, such as Grimsby and Hull, are altogether different from those which obtain among the small inshore communities with which we have just been dealing. Deep-sea fishing, involving prolonged absence from port in every possible kind of weather, can only be carried on in decked vessels of considerable size, and manned by a number of skilled hands; and we find the fisherman, instead of being owner or part owner of the boat in which he fishes, is usually a hired servant, receiving a regular wage, and interested to no considerable extent in the pecuniary success of his fishing operations. In some cases, which are becoming, I am told, fewer in number every year, the skipper is also the owner of his vessel,—either actually so, or, much more frequently, owner only in name and on sufferance of the mortgagees. By far the greater number of vessels, however, are in the hands of companies or large private owners, and the hands engaged in working them are simply the servants of the owner. The method or rate of payment differs according to the rank of the hand. Thus the master or skipper, and the mate or "second hand," are paid in shares of "clear money" or the profits, and are held responsible in corresponding shares of the expense if the vessel is worked at a loss. In the case of a steam-trawler the expenses reckoned in estimating the clear money are coal, engine-room expenses, ice, and men's food, and 5 per cent. on the price obtained for the catch. After these items have been deducted from the gross receipts of the voyage the skipper gets "one share, and one quarter and one half-quarter" of the balance, which is divided into fourteen shares. The mate, or second hand, takes one share and one eighth. Both skipper and mate pay for their food, provided at retail prices from the company's stores by the steward. The "third hand" and the "deck hands" are paid a fixed salary, are provided with food by the owners, and are also, in common with the apprentices, allowed to make what money they can by the sale of "stocker bait," a term which formerly included a number of the less valuable kinds of fish. Some years since the owners, finding a decrease in their profits, and noting, no doubt, a rise in the price of fish which had previously been hardly saleable, came to an arrangement with the men by which the latter surrendered their rights to the "stocker" and received an increase of pay, which was supposed to compensate them for the loss. They have, however, retained the right of selling fish-livers for their own profit. The livers are stored in ordinary petroleum casks, and sold to oil refiners at ten shillings per cask. As may be imagined, it takes the livers of a considerable number of fish to fill a cask, even when liberally adulterated with sea-anemones (*Actinoloba dianthus*), so that the profits accruing are not excessive. I have known instances in which the men have been allowed to sell such fish as gurnards and rays for their own profit, but I believe that the owner is strictly within his rights in laying claim to everything that comes on deck. It will hardly be credited, perhaps, that within the memory of living fishermen, haddocks were a perquisite of the apprentices!

In a steam-vessel the engineers receive a fixed wage, and have no interest whatever in the catch. The coal-trimmer is usually an apprentice; his duties are by no means confined to trimming coal, and he receives his share of the "stocker," besides many attentions from the superior members of the crew, with which he would probably be glad to dispense. Line-fishermen, besides their regular pay, receive a certain sum per head of fish, but this is not the case with trawlers. In all cases the owner finds everything in connection with the equipment of the vessel, and provides a steward or cook, who is paid a fixed wage. The remainder of the crew are paid weekly wages, and are supplied with food by the owners.

The skipper of a steam codman receives 9 per cent. of the "clear money." The mate gets £1 per week, and 3*d.* in the pound on the clear money; deck men £1 per week and 2*d.* in the pound on the clear money. The engineers get respectively £2 5*s.* and £1 15*s.* and their food while at sea, but take no share of the catch.

Now the conditions of service, which I have endeavoured to sketch, obviously involve a social atmosphere very different from that which one encounters in the small communities of inshore fishermen.

The duties of the deep-sea man commence when he goes on board his ship; and when he has landed the fish and cleaned the vessel his interest in her ceases until she starts on her next trip. In consequence his family, if he possess one, takes no sort of share in the fishery. Again, the large size of the vessels and gear employed in the deep-sea fisheries involves a considerable intricacy in the technique of fishing operations, and thus to a great extent the men become specialists either in trawling or lining: some adaptive geniuses of course there are, but as a rule a man is either a trawler or a liner, and not both, and the members of these two branches of the profession appear to have surprisingly little intercourse with each other. But if there is not much intercourse, neither is there much friction, and you shall hear from ten inshore line-fishermen more abuse of trawlers in ten minutes than you shall hear from a hundred deep-sea liners in a year. The fact appears to be that the social conditions of the larger communities, if not very obviously conducive to the higher graces of manners and speech, at any rate tend to evolve an independence and self-reliance which are not always as evident among the inshore men as they might be.

It has often been suggested to me by persons well acquainted with the district that the conversion, for part of the year, of some of the smaller fishing centres into watering-places has had rather a demoralising effect on the fishermen. The prospect of being able to make a good deal of money by pleasure-boating in the season is said to make the men rather careless of the fishing, and it can be well understood that a fisher-lad is not likely to attain to great skill in his profession if he employs a large part of his time in other pursuits. Indiscriminate charity is also said to have had a bad effect; and, indeed, it can hardly conduce to a man's independence to have benevolent old women advertising for his relief!

The deep-sea fishing is not entirely confined to trawling and lining, though these pursuits occupy by far the largest proportion of the Grimsby fishermen. In addition, a certain number of smacks are engaged in deep-sea oyster dredging, and there is a considerable fleet of "whelkers." Judged by Hull and Grimsby standards, the boats engaged in whelking are comparatively small, but since they remain at sea for prolonged periods they may conveniently be classed among the deep-sea craft; they are all sailing-vessels, as are also the larger boats engaged in oyster-dredging. Lining and trawling are carried on both by smacks and steam-vessels. The former are nearly all first-class vessels, varying from 95 to about 60 tons (displacement measurement), though there are a few liners of small size. The steam-vessels do not differ from each other greatly in dimensions, but they are still undergoing a process of evolution. The present fleet includes a few which are simply smacks into which engines have been put, while the rest have been laid down as steam-vessels, and exhibit various stages of improvement according to their age. The very newest departure is the adaptation of the petroleum engine to fishing purposes, an enterprise which has yet to stand the test of experience, but which seems to have all the elements which should conduce to a successful issue. Steam is not utilised in fishing purposes for motive power alone, since even the sailing trawlers are fitted with a small engine for heaving up the trawl and hoisting the sails. The lining vessels have no use for steam except as motive power, since, as the long-lines are hauled by the ship's boat, no adaptation of steam-power to an "iron man" is practicable. These vessels are of course fitted with a well, while trawlers have an ice-room and fish-hold. At least one steam-vessel, the S.S. 'Aquarius' of Grimsby, has a compartment which can be filled with water as a well for lining purposes, or pumped dry to serve as a fish-hold, and can therefore be utilised for either branch of the industry. In the majority of lining vessels there is no means of closing the apertures by which the water is admitted to the well, an obvious disadvantage when it is necessary to bring the vessel a considerable distance up an estuary or into a harbour, where the low specific gravity and general impurity of the water are prejudicial to the living freight. If the well is fitted with valves, good water can be brought in from the open sea, but there is a disadvantage on this side also, since, if the ship has to lie in dock some hours before unloading, the water stagnates and the fish are asphyxiated. The leading spirits of the fishing community have, however, proved equal to the emergency by devising an air-circulation. The device has been arrived at, I believe, quite independently, although the principle of an air-circulation has long been familiar to those interested in aquaria, and we have here an instance of a case in which the "practical" man might have saved himself much expenditure of ingenuity by a little attention to what is being done by his scientific brethren. It may be urged, perhaps, with equal truth that the biologist should have perceived the opportunity of an economic improvement, and I have to confess that the idea of adapting an air-circulation to a ship's well did not occur to me until last spring, when I had occasion to fit such a circulation to the Cleethorpes tanks. On communicating my ideas to a smack-owner I found that he was at that time actually engaged in patenting an apparatus essentially similar, but devised entirely by himself and friends.

The preceding remarks will perhaps suffice for our purpose, without entering into a long technical description of the various classes of fishing vessel. Indeed, such is hardly necessary, as Professor M'Intosh has recently published in the Association's Journal a detailed account of Scotch steam-trawling vessels, and the later types of these agree with the Grimsby boats in all essential details. It may be remarked, however, that a deck-house is confined to Aberdeen boats, and no English trawlers that I know of carry an otter-trawl.

Grimsby steam-trawlers are divided into two classes. Those ranging from 35 to 40 tons nett register are spoken of as "inshore" boats, though it must not be supposed they work what are, strictly speaking, inshore grounds. These boats carry a 50-foot beam-trawl and 200 fathoms of warp. The larger steam-trawlers range from 50 to 70 tons, and carry a 56-foot beam and 250 fathoms of warp. The bridles in both cases are 26 feet long.

The smaller trawl-smacks carry a beam of 44 feet, and 140 fathoms of warp. The larger ones have the beam 50 feet long, and 180 fathoms of warp. The warp of a steam-trawler is of wire, smacks using warps of manilla rope.

The sailing trawlers at Grimsby and Hull are fast being superseded by the steamers. The latter increase every year, while the former are gradually disappearing, those which succumb to wreck or old age being seldom replaced by new ones. At Boston the deep-sea trawling industry was started by steamers, and has never been carried on by smacks at all.

At Lowestoft it appears that steam-trawling has been considered unsuitable, and that the smacks are increasing. Moreover, at this port a class of vessel smaller than that generally in use at the Northern ports finds most favour, and the modern type of smack is only from about 45 to 50 tons. Yarmouth and Ramsgate smacks are, I believe, essentially similar to those of Lowestoft.

It is hard to see why Grimsby men should consider that the large smacks are the best, while Lowestoft men prefer the small ones, since I know of no difference in the conditions under which the fishing operations are carried on from the two ports to account for this. The Grimsby smack has been evolved, chiefly by gradual increase of size, from the much smaller South coast boats, which first opened up the North Sea trawling; and every step in their enlargement seems to have been viewed with apprehensions, which were never justified by the results. The largest I know of exceed 90 tons register, and it is impossible to say that the size would not have been further increased had not the immensely superior catching powers of the steamers practically diverted all piscatorial ingenuity into a new channel.

One branch of trawling remained exclusively in the possession of smacks until quite recently. This was fleeting,* the function of steam being confined to the carriage of fish, caught by fleeting smacks, to market; but within the last two years there have been launched several steamers designed especially for fleeting purposes, and no doubt, if there remain anything to trawl for, the sailing smack will be gradually driven from this, her last vantage-ground.

CHAP. II.—A "VOYAGE" ON A STEAM-TRAWLER.

It may be of interest to give a brief account of a trip on board a trawling vessel, as giving some little insight into the life led by our deep-sea fishermen when engaged in their calling.† For this purpose a voyage in July, 1893, as having covered more grounds in one trip than is usually the case, will best serve. The ship, a steam-trawler, was due to sail with the morning tide, and I found my way on board, at the hospital dock, in good time. The engineers were already on board, and one by one the rest of the crew dropped in, the skipper arriving just as it was time to make for the dock gates. Subject to occasional exceptions, the skipper has absolute discretion as to what grounds he will fish, and in this instance, as far as I could gather, our skipper had decided to try for a catch of small plaice, and anything else he could come by, south of the Horn Reef, on the Danish coast. However, the plans of skippers are notoriously changeable, and that they should be so is perhaps as good a proof as any of the uncertainty which attends the North Sea trawl-fishery in its present condition. We were hardly clear of the dock gates before we met another trawler of the same firm coming up the river. Professional etiquette, not to speak of other considerations, demanded that both skippers should slow down and have a parley, and the usual query "How's trade?" was, for a wonder, answered with "A good living." Inquiries as to where this "good living" was to be found elicited the information that plaice were plentiful "below" (north of) the Reef, so our skipper determined to give the ground a trial, and laid his course accordingly on clearing the Spurn Lightship. I may here remark that fishermen at sea always appear most willing to give each other information as to the fish to be found on grounds which they have been working. Whether it is correct information or not is another matter.

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* In "fleeting" the trawlers remain on the ground, and transfer their catches to carriers instead of returning to port themselves with the catch.

† I gladly take this opportunity of saying that I have always found both owners and skippers most willing to give me a berth on board their boats, and have received the greatest possible kindness and assistance at sea.

Having left the river and got a clear course for the Horn Reef Lightship, we have now leisure to have a look at the principal members of the crew. Pretty nearly all the nations of the earth are represented in the North Sea trawling community, from Kroomen to Faröe Islanders, and on this occasion our skipper was a Prussian, and his mate a Dane. The former has the reputation of having landed more undersized plaice than any other man in the world, and it was chiefly this consideration that induced me to seek a berth on his boat. He was fully acquainted with the object of my inquiries, and was, and I believe is still, as anxious as any man that the destruction of small fry should be stopped, but made the perfectly candid reservation that, as long as there was a market for such stuff, he did not see why he should not make use of his experience of the coast, and knowledge of the habits of the fish, to catch more of them than anyone else could. It would be libellous to suggest that a wholesome contempt for the three-mile limit may not have been an unimportant factor in his previous successes. He was excellent company, and certainly did not betray his foreign origin by any ignorance of the intricacies of the English language, as commonly spoken at Grimsby. To his other accomplishments he added that of the violinist, and usually beguiled the tedium of the evening with frequent renderings of the one tune with which he appeared to be acquainted.

The mate, a huge Dane, was known as "Tom," because, I suppose, that was not his name. He was a good-natured soul, and submitted to any amount of chaff from pretty nearly every member of the crew, but knew perfectly well, nevertheless, how to get the required amount of work out of them. The captain and he were very fond of indulging in elephantine gambols, and gave and received, with perfect unconcern, blows which seemed calculated to stave in the side of a hogshead. The chief engineer, of course, had been brought up in that calling, but his subordinate was an ex-dragoon, whose capabilities did not extend much beyond stoking. The steward had served twenty-one years in the Black Watch, and had lost a thumb, not in the service of his country, but from the sting of a weever (*Trachinus draco*), which he had incautiously handled on one of his earliest voyages. The symptoms, as described by him, appeared to be precisely similar to those which one reads of as resulting from the bite of an adder. The rest of the crew do not call for special remark, but, taking them all round, they were as pleasant and good-natured a set of fellows as one need wish to meet with in any rank of society. They all arrived on board in shore-going costume, looking very unlike the fisherman of romance, and it was not until the evening that they got into their jerseys, oilskins, and sea-boots. The skipper despised the latter altogether, and affected a very ancient pair of "clumpers" (shoes with a thick wooden sole), when the deck was too wet for even him to be comfortable in stockings only. Once the sea-going kit is donned, I have never observed that any change is made until the boat reaches the river on its homeward voyage; and ablutions, if carried on at all, are certainly infrequent. However, any part of the person not covered by oilskins is sure to encounter plenty of water, if no soap.

To resume our narrative, the south-westerly wind had freshened very considerably before we made our land-fall, and the skipper remarked that such weather would have been certain to have spoiled his chances of a catch south of the Reef, since fish will not stay there with heavy weather from that direction, especially so late in the season. The weather had its usual effect on myself, since, though my business takes me a good deal to sea, I am an incurable victim to *mal de mer*, and on this occasion I spent the usual day or so of misery before I was thoroughly right. It did not prevent my noting the duration and locality of hauls with the net, or the fish caught, but tow-netting and microscope work were out of the question. The skipper was exceedingly sympathetic, and prescribed remedies, but to my exceeding good fortune had mislaid the key of his medicine chest, so I escaped with nothing worse than the sea-sickness itself. I should say that the decoction known on North Sea smacks as "tea" had made its appearance not long after we left the Humber.

It consists of a quantity of tea, a tin of condensed milk, and about two pounds of sugar, boiled together for some hours in a huge kettle. Day and night this remarkable beverage is on tap as long as the vessel is at sea, and every man has a mug of it within reach, whatever he may be doing. I can confidently recommend it to anyone who wishes to experience most of the sensations of sea-sickness without the trouble of going to sea. For any other purpose I have nothing to say in its favour, nor, I believe, have those who have medical cognisance of the piscatorial constitution.

Our first haul was made late at night on the Danish coast to the north of the Reef, and for a day and a half we worked along northwards, fairly close inshore, without any luck at all. A heavy sea was running, and we did little but tear our nets, so that all hands were busy mending one net while the other was fishing. The skipper of a steam-trawler appears to have no actual duties beyond that of command, except when the net is being shot or hauled. In the first case he takes the helm, and in the last he has charge of the steam-winch. He takes no share of the watches, nor does he assist in the cleaning and stowing of the fish, but in mending the gear he generally lends a hand. The skipper should be, and generally is, the best hand on the vessel, and with the netting needle certainly no one could come near our particular skipper. All hands, except the engineers, have to turn out when the trawl is shot or hauled, but are otherwise divided into watches. The usual practice on steamers is to make two hauls of six hours at night; and the same, or one of twelve hours, by day. On bad ground, or when fish is very plentiful, shorter hauls are made. Sailing vessels, when "fleeting," usually shoot towards nightfall and haul by daybreak, the daytime being occupied in getting their fish on board the cutter and beating up to windward towards the place where they shot on the previous evening. "Single boating" smacks either follow the same practice or take whatever chance of fishing may be offered by the wind, and of course all sailing vessels are dependent on the vagaries of the weather to an extent from which the "wind-jammers"* are exempt.

The technique of hauling is as follows.† The ship is brought round broadside to the wind, and the main engine stopped. The skipper takes charge of the steam-winch, and the warp is got in until the shackle appears. Then the after-bridle is unshackled and passed to the stem, where the mate makes it fast to a hawser borne on a separate drum of the winch; the after-head is made fast to the ship's side as soon as it arrives in place, while the fore-head is put on to the tackle and hoisted on board. All hands lay over the beam, which is now along the gunwale, and get in the net by hand, getting the ground-rope on board as soon as possible to prevent any fish escaping. As soon as may be a rope is got round the neck of the cod-end, and the bag of fish is hoisted on the tackle and swung inboard, forward of the steam-winch. If the other net is to be shot at once, the bag is usually left swinging until that operation has been accomplished. Then the cod-end is untied, and the contents come down on deck with a rush. The crew at once set to work to clean the fish, pitching them as they are cleaned into the different pounds, which have been formed on deck by letting boards into slots provided for the purpose. Turbot are most carefully bled, and care is taken that they only lie on the coloured side, as the natural position spoils their appearance for market. In winter, plaice are often brought in "alive," *i. e.* with the viscera intact. After being cleaned, the fish are thoroughly washed, with the aid of the hose, in large tubs, and then stowed away in separate compartments in ice in the fish-hold. The rubbish and viscera are shovelled overboard and the decks washed.

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* Steam vessels.

† The mouth of the trawl is formed above by the "beam" terminating in the "heads" or "irons," and below by the heavily weighted "ground-rope." From each "head" runs a "bridle;" the two "bridles" meet at the "shackle," which is connected with the winch of the trawler by the "warp."

The regular round of duty is broken only by meals, and it may be said that the steamboat men live well, though I believe the same is not always the case on smacks. All meals take place in the saloon, but as it will not comfortably hold all the crew at once, the officers—skipper, second hand, and third hand—and the engineer off duty are first served, and then give place to the rest. Breakfast appears at about 7 a.m.; it consists of tea, bread and margarine, and fried fish, generally dabs. Dinner arrives at twelve noon, including hot meat, generally two vegetables, and a pudding of some description. Tea is at six, and consists of cold meat, if there is any, bread and margarine, biscuits and cheese, or jam. Excellent bread is baked by the steward several times a week. The only beverage is tea, except that cocoa or chocolate is sometimes served out after the midnight haul, and anyone who wants it gets a biscuit at the same time. I have not seen beer or spirits on any fishing vessel, and I believe teetotalism is the general rule with Grimsby fishermen when at sea, whatever may be their custom when ashore. Personally I have seen nothing of "coopers," but these work chiefly among the sailing fleets, with which I have had little to do. I remember, during the trip of which I am writing, that we were hailed by a Dutch salt-herring boat who offered us a bottle of Schnapps for a dish of fish, an offer which our skipper declined in language which, if not concise, was certainly lucid.

To resume our narrative. The coarse weather continued for several days, but after passing to the northward of the "Holman" (Hantsholm) our skipper tired of tearing his net in the heavy swell so close inshore, and steamed outwards to shoot inside the "rough" which runs north and south about fifteen miles from the Danish coast. It is, I believe, what is known to geologists as a "moraine," and consists apparently of detached boulders of various sizes. We got very little fish, but venturing too far out we managed to capture a lump of granite (resembling that from Shapfell) about three feet long by two in breadth. It is the custom when a big stone or other impediment to trawling is brought up in the net, to keep it on deck until the Humber is reached. It is then pitched overboard off the New Sand Buoy, where it will be in nobody's way. Tom, however, would not be bothered with this particular geological specimen, and had it lowered overboard as soon as the net was cleared. The skipper remonstrated, remarking that some one else might "get" it. "Let 'em get it," responded the mate, "they'll get nowt else here,"—which seemed likely enough, to judge from our own success.

By this time I had got to work with tow-nets and microscope, and the antics of Copepods and "such small deer" were a source of constant delight to the crew. More astonishing still were the minute pelagic stages of the turbot, which I believe came then for the first time under human ken, though my colleague Mr. Cunningham had already discovered the older pelagic forms at Plymouth. I was able also to introduce my friends to the mystery of artificially fertilising fish eggs, and had hatched out a small family of turbot in a pickle-bottle before we got back to port. Developing eggs of different sorts were of course constantly captured in the tow-nets, and every night the microscope would be requisitioned for the use of the crew, to see how the youngsters were getting on, and to find out how it was possible to tell one from another.

I never lacked assistance in hauling my "trawls," as the skipper elected to call them, and by the end of the voyage that worthy had become comparatively expert in sorting out and pickling the young fish. To subsequent tow-netting operations, carried out by him independently, the world of science is indebted for the completion of the series of the pelagic forms of the turbot and for the discovery of several stages of the mackerel which were previously unknown.

To return to the business of the ship, we moved along inside the "moraine" to a point about thirty-five miles north-north-west of the Reef, and got a few haddock and plaice, with occasional turbot, brill, and hake, but hardly enough to pay expenses. We fell in with a couple of foreign steam-trawlers, but they had had no luck either, so our skipper determined to strike out for fresh ground altogether. He had rather a hankering after the grounds south of the Reef, as the weather was moderating, but finally determined to try the Great Fisher Bank, so we shaped our course northerly, taking a night-haul by the way on the oozy ground to the east of the Dogger. Going on deck as the trawl came aboard, I was greeted with a sickening odour, apparently of rotten onions, but proceeding in reality from a vast mass of sponge and mud with which the net was choked. There were hardly any fish worth keeping, so we steamed straight on until the leadsman felt the Bank, and then proceeded to hunt about for what the skipper considered the most likely part at that season of the year. The Bank is of great extent, and navigation is not, perhaps, conducted by fishermen in the most exact manner, but in course of time we hit on the "Inner Shoal-water," and got decent, if not large, catches of haddock for some days. The Bank has only been regularly worked by trawlers during the last ten years or thereabouts, and its intricacies are known to comparatively few, of whom our skipper claimed, with apparent reason, to be one. He told me of several parts where the soundings are such as the Admiralty charts (accurate as far as they go) give no hint of, and of one spot in particular, known only to himself and a friend, where splendid bags of fish are always procurable, if you can only find it. On this occasion both coal-bunkers and fish-hold were too empty to allow of any time being spent in what might be a fruitless quest after all, so we remained on much the same ground as long as we could get our fish, chiefly haddocks. Occasionally we got among the dense masses of lemon or scented weed (*Flustra foliacea*), which covers a great part of the Bank, and, especially when using the heavy ground-rope,* we brought cartloads of it aboard. Entangled among it were quantities of tiny cod; and here too we got a few haddock, with the adult conformation, but smaller than any which had previously been immortalised in alcohol. I was surprised to find the anemone *Chondractinia digitata* extremely plentiful; it was almost invariably attached to the shell of a living almond or smooth whelk (*F. antiquus*). The habits of naturalists have hitherto induced them to consider this a rather rare species. I brought many alive to the Cleethorpes aquarium, and was able to verify the correctness, as to colouration and certain other points, of the drawings and description given by Gosse, on the authority of J. Alder, the only actinologist who appears to have been acquainted with living examples. Other equally interesting actinians were met with, and I believe that the obscurity in which several genera are now involved might be cleared up by material collected from the Fisher Bank and adjacent grounds.

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* Some boats have the two trawls fitted with different ground-ropes—one rather light, designed for the capture of haddock; the other weighted, for flat-fish.

After several days on the Bank our skipper began to think of getting nearer home, so a course was steered for the west end of the Dogger, where we had pretty fair catches, and finally we ran home after an absence of twelve days. It was not possible to say anything really complimentary about the weather the whole time, and luck was completely against us at the start, but by sheer perseverance the skipper had managed to get together a very fair "voyage" of fish. Indeed, I am of opinion that what is called "luck" has a less share in determining the fortunes of a fisherman than is generally attributed to it. A man who will have fish, gets them somehow or other. Many men, no doubt, on finding a poor supply after running over to the coast of Denmark, would have simply lamented their ill-fate and fished about on the same ground until the coal ran out, and then come into port without enough to pay wages. Not so our friend, who got his fish, though he had to steam pretty well all round the North Sea to get them, covering about 700 miles, without counting actual fishing operations.

Fishing can hardly be called a lucrative business at the best of times, and the discomforts are greater than can readily be imagined by anyone who has not witnessed, and to some extent taken a share in them. It is astonishing how extremely cold it can be even in the height of summer, with a keen wind blowing and the water splashing all over you as you sit cleaning the fish on deck at one o'clock in the morning In winter of course the discomforts are intensified. It happened that when I was at sea in March, 1892, we encountered a snowstorm which lasted two or three days. The cold on deck was intense, but of course the work had to be done. When the trawl-beam comes aboard, all hands have to get in the net. The boat is broadside on to the sea, rolling her utmost, as the sails are nearly always left standing to intensify the roll, so as to make it easier to get in the slack of the net as she dips; and laying over the beam under such circumstances of weather, with the sea breaking all over you, is about as unpleasant a job as a man need wish to avoid.

CHAP. III.—AN OUTLINE OF THE RISE OF TRAWLING IN THE NORTH SEA.

Although the North Sea trawling industry has long exceeded in importance that which is carried on along the rest of the sea-board of the United Kingdom, it is probably well known to most people that this method of fishing is not, so to speak, indigenous to the district, but of comparatively late introduction.

No serious attempt at a history of the origin and progress of trawling has yet been made, and it may be feared that by the time it is attempted some attention will also have to be given to its decline. The few remarks which I have to make on the subject here are put forward in all diffidence. They contain only the barest outline of the history, and rest entirely upon information which I have collected from old fishermen, and others who have taken an interest in the trade. I know of no documentary evidence to which reference can be made, but from the general harmony of oral accounts derived from different sources I believe the facts, as far as they go, are approximately correct.

The date of the discovery of the trawl, or of any fishing instrument at all resembling it, is altogether uncertain. On our own coasts the doubtful honour of its introduction seems to have been disputed by the fishermen of Brixham and Barking, but without claim on either side to any very remote antiquity of practice. It seems possible, however, that a fearful engine described as a "Wondyrchoum," against the use of which petitions were presented in the Parliamentary Session of 1376–7, may have more or less resembled a trawl.

Be this as it may, it seems at any rate certain that beam-trawling had been established as a regular industry at Brixham at a period considerably antecedent to the outbreak of the French wars. The boats in use then were quite small, and the trawl-gear could be carried with ease on a man's shoulder. The war naturally interfered greatly with the prosecution of a fishery on the south coast, although in some ways, less reputable than the practice of their legitimate industry, some of our south-coast fishermen seem to have found it not altogether a source of loss.

At the close of the war in 1815 there was a revival of the trawl-fishery, and enterprise began to manifest itself in the search for new grounds. I believe that about this time an attempt was made by the Brixham men to establish themselves at Dublin; but the honour does not seem to have been appreciated by the native fishermen, and the adventure was abandoned. About 1818 we hear that a certain number of Brixham trawlers migrated eastwards, and established their headquarters at Dover, trawling in Rye Bay and the neighbouring grounds. In or about 1821 the North Sea may said to have been first reached, since at that time the Brixham men began fishing off Ramsgate. The chief ground seems to have been the New or Sandettie Bank, where fine takes of turbot were made for some time, and a more or less regular system of transporting fish to London was now organised.

The tide of migration crept slowly northwards, as new grounds were discovered and in turn exhausted, and about 1828 the system of "fleeting" seems to have been first adopted. Certain boats, instead of returning to port as soon as the catch had been made, banded themselves into fleets, and the catch of the whole fleet would be collected every day by a fast "cutter," and conveyed to market. The system appears to have been organised by fish merchants, who found the cutters and paid contract prices for the fish delivered. It prevailed only during the summer months. Harwich was the port chiefly engaged in these operations, but Barking seems to have had considerable importance as a trawling port either at this time or a little later. The Brixham men, I believe, were in the habit of returning home for the most part in the winter, and, throughout the migration, the most northerly ports reached were always used at first as summer stations only.

About 1830 the discovery of the productive grounds along the Dutch coast gave a great impetus to the trade, and smacks increased both in number and average tonnage. Brixham and Ramsgate seem to have had an aggregate of about fifty-five sail engaged in trawling operations. Local enterprise opened out certain fishing grounds off Yarmouth and Lowestoft; trawlers were hired for this purpose from Ramsgate and Barking, and the fish, chiefly soles, were despatched to London in light waggons, with relays of horses at various posts.

The Dogger was certainly worked by trawlers some time between 1830 and 1840, but it does not appear that it was at first a very remunerative ground. Haddock were of little or no value, and the Dogger plaice are said at first to have been large coarse fish. Boats continued to push northwards, and before 1840 Hull and Scarborough were summer trawling stations, but very little frequented in the winter. The average tonnage was about twenty-five to thirty-five.

One of the most important events in the history of the industry was the discovery, in the winter of 1837, of the now famous sole-ground known as the Great Silver Pit. The master of a Hull trawler, William Sudds by name, being blown out of his reckoning by heavy weather, had the curiosity to shoot his gear in the unusual depth of water which his soundings revealed. The result was an enormous draught of soles, and the circumstance gave rise to the institution of a regular winter fishery. Boats and capital were attracted from all parts, and Hull became the principal centre of the North Sea trawling industry. The tonnage of smacks also underwent a rapid increase, culminating in that which is now in general use.

What has probably been of more lasting importance to the trade than the transitory productiveness of the Pits, was the introduction of haddock-curing at Hull, which took place about 1840. The haddock is after all the trawlers' best friend, as alone of all the trawl fish it seems able to make headway against the devices of man. Before curing was introduced, there was practically no market for these fish. I am told that only the largest were ever thought worth bringing ashore, and sometimes not even these. Statements have been made that there were no haddock on the Dogger when that ground was first worked, but the balance of the evidence obtainable shows that the fish were exceedingly plentiful there, though of no account, for the reason I have mentioned.

The introduction of ice and the adaptation of steam to fishing purposes occurred, almost simultaneously, about 1850. Steam power, I believe, was first used in the North Sea by Mr. Rushworth, and in connection with line-fishing. The advantages of ice are obvious, since its use permitted the boats to make much longer voyages than had previously been possible. Steam does not appear to have been very extensively used until about 1860.

It will have been noticed from the foregoing remarks that the development of the North Sea trawling has been effected entirely by fishermen from the south coast, and to the present day we find that the bulk of the trawling fraternity are the descendants of south-coast men. Of the rise of the deep-sea line fishing I have little knowledge, but I believe it is also owing, at least in great part, to exotic enterprise. In most of what are now large fishing centres there have existed, in all probability, minor fisheries from a very early period, which have been to some extent masked by the more important modern methods. I do not know that this was the case at Hull; while at Grimsby, which has not yet been mentioned, there was certainly no indigenous fishery of any importance.

Grimsby, in fact, is an altogether modern fishing station. Early references to the port make no mention whatever of any existing fishery, though the adjacent hamlet of Cleethorpes seems to have been always occupied in longshore fishing, whenever its inhabitants had leisure from less reputable pursuits. At Grimsby the existence of a very indifferent natural harbour permitted a certain amount of shipping trade to be carried on from the earliest period of English history, and in 1801 this natural harbour was considerably improved.

The real importance of the port, however, dates from the time at which it began to attract the attention of the Manchester, Sheffield, and Lincolnshire Railway Company. The Company acquired possession of the existing dock, now known as the Old Dock, and proceeded to construct new ones, the first of which was opened in 1852. Additions have subsequently been made, and the dock accommodation at the present day exceeds 100 acres; the population, 3688 in 1841, is now something over 60,000.

The bulk of the dock accommodation is, and has been, devoted to ordinary trading vessels, but the Company seem early to have cast covetous eyes upon the fish trade at Hull, and to have offered every inducement in their power to obtain a share of it for Grimsby. The latter port possesses natural advantages over its older rival, being nearer the mouth of the Humber, and in more direct railway communication with the principal markets,—facts which the fishermen and smack-owners were not slow to appreciate. Special accommodation was provided for fishing vessels, which now have two docks, covering an aggregate of twenty-three acres, and two graving docks, devoted to their sole use. The progress of the trade can in some way be judged from the Railway Company's returns: previous to 1854 there was little or no inland fish traffic; in 1854 the Company despatched 453 tons, in 1860 4587 tons, in 1870 26,234 tons, in 1880 43,415 tons, and in 1893 80,134 tons. An export traffic was also established, and reached about 3000 tons in 1877, but has not materially increased since that year.

It can well be understood that the development of the new fishing port was not viewed with any particular favour by its neighbour on the opposite bank of the Humber, and for many years the rivalry between Hull and Grimsby is said to have been keen and bitter, though nowadays it has no more than a merely formal existence. Hull has been gradually outclassed as a fishing station, not by any intrinsic decay, but simply by the extraordinary development of the Grimsby trade; it has merely had to take the second place in the deep-sea trawl and line-fishery of the nation, and shows no signs of relinquishing it for a lower one.

The Boston trawling industry is the most modern of all, since it was originated within quite recent years under the most modern auspices. There never has been a first-class smack trawl-fishery at Boston, doubtless owing to the intricate navigation of the Wash. This presents but little difficulty to steam-vessels, and the steam-trawlers, devoted to the deep-sea trade, in no way interfere with the pre-existing inshore fisheries.

The later developments of the North Sea trawl fishery can only be very briefly summarised. Boats found their way along the

Continental coast by gradual stages, opening up the grounds north of the Horn Reef about 1868. The liners, or codmen, seem to have been the pioneers in the exploration of the more central parts of the North Sea, since the Great Fisher Bank had been frequented by them for many years before it became a recognised trawling ground. I believe it was first trawled about twenty years ago, but has only been generally resorted to as a winter ground during the last ten years.

The Iceland grounds were also discovered by liners, and it was not until 1891 that they were first visited by a trawler. They have been worked, though not at great profit, by a certain number of steam-trawlers ever since; whether the fishery will continue is doubtful, but certainly the local authorities have done their best to discourage it. I have given rather a detailed account of the early condition of this fishery in the Association's Journal (vol. iii, 129), but, in view of recent developments, I fear that certain predictions I ventured to make will have only the average value of prophecy.

CHAP. IV.—THE INTRODUCTION OF TRAWLING AT A NORTHERN FISHING STATION, AND ITS INFLUENCE ON THE FISHERY.

In answer to my inquiries on the aspect of fishery matters at Sunderland, and on the past history of the industry at that port, my friend Mr. T. N. T. Potts has kindly drawn up the following sketch, which I make no apology for publishing *in extenso*.

"I am forty-two years of age, and have resided in the locality of Sunderland since childhood. The sea and the sea-shore are the first things I can remember, and as a child I took the greatest interest in its living creatures. My earliest knowledge of the fishing will date from about thirty years ago. At that time fishermen really were fishermen, their forefathers before them had been fishermen, and they brought up their families as fishermen. All did what they could; the girls and younger branches of the family sought bait, while the boys who were old enough went with their fathers to the fishing. In many cases the fishermen made their own lines and nets, during bad weather when they could not get to sea. At that time each family possessed their own 'cobles' (local boats, of which there are two sizes, the large herring cobles about 30 to 40 feet over all, and the small cobles about 20 to 30 feet over all used for line-fishing, crab, lobster, and salmon fishing), nets, lines, and gear sufficient to conduct the various kinds of fishing suitable to the season. At this time stake-nets were allowed for salmon fishing, and many salmon and sea-trout were taken in this manner.

"At the end of the herring season (then about the end of September) they went to the Tees with their herring cobles for mussels, which they laid down in sheltered positions to form 'scarps' (a local name for mussel-beds) to last them over the winter; the herring cobles were then hauled up, and the line-fishing conducted in their small cobles.

"All bait was locally procured, and such a thing as sending away for bait was quite unknown. In the winter they prosecuted the haddock or small-line fishing, which was conducted comparatively near to the shore; this they did in small cobles, and it is thus managed:—Three men, or three men and a boy, have a coble amongst them. Each man provides what are termed two half-lines; each half-line is coiled up on a flat-shaped basket, and consists of six or seven pieces of line, each piece being 65 fathoms. The hooks are whiting hooks, and the fishing is for whiting and haddock, though not infrequently cod and ling of large size are taken in consequence of their having swallowed a whiting or haddock already hooked. These lines are baited with mussel, limpets, and sandworms, and, if possible, shot before daybreak, and the principal time for this fishing is from October to March.

"As the season advanced, the same cobles and crews would commence the long-line fishing, at which cod, ling, turbot, halibut, conger, skate, and other large fish are taken. Twenty years ago, skate were of no value, and were cut adrift as they came to the surface, and they were hooked in enormous quantities, so much so as to be a nuisance to the fisherman; but since steam-trawling has commenced, they have become very scarce, and a moderate-sized skate will sell at the fish-market for from 5*s.* to 7*s.*

"The lines used at the long-line fishing are much stronger, the hooks of course being larger and stronger also, and the fishing conducted at a greater distance from land. In the first place the small lines were shot as in the haddock fishing; the long lines were then got ready for shooting at the after end of the coble, and as the small lines were hauled in, the haddock, whiting, and other small fish would be used as bait for the large lines, which were shot over the stern as the small lines were hauled. The large and dead fish would be cut up into suitable sized baits; the live fish were hooked by the lip, thus forming a very attractive bait. The long lines were then buoyed, and left until the next morning. Of course this cannot now be done, as the lines would be swept away by steam-trawlers. The quantity of fish taken in this manner was immense, considering the amount of line then used, about five or six baskets being as much as a coble could use, and I can well remember as a boy having often to throw out the ballast to enable the coble to carry the fish, which often amounted to several cart-loads, while now thirty baskets of line may be shot 100 miles off, for not a third the quantity of fish. On one occasion last winter while fishing with the 'Fingal' we shot twenty-four baskets of line 100 miles off the land, amounting to over 3000 hooks, each baited with a whole herring, and only caught eleven fish! Many other steam line-boats can give similar cases. Since the commencement of steam-trawling, this fishing has been abandoned by cobles, owing to the fish having become extinct on the inshore grounds, and to the impossibility of allowing lines to remain at sea overnight.

"At this time there were sailing-trawlers belonging to Hull and Grimsby, fishing on the Dogger Bank, and occasionally landing a catch of fish at Sunderland; and several sailing-trawlers were built and owned in Sunderland, and worked on the same grounds, and in the same manner as the Grimsby trawlers.

"These vessels did no appreciable harm to the inshore fishing-grounds, as they seldom if ever fished within fifty miles of the land.

"About twenty-five years ago, in the summer, owing to that year being exceptionally hot, and prevailing calms preventing them reaching their fishing-grounds, two of them, the 'Henry Fenwick' and the 'Fearnot,' were towed about the inshore grounds by the steam-tug 'Heatherbell,' and I remember having made several trips in them. The mode of working was as follows:

"The 'Heatherbell' would go to sea about noon, and join the two vessels from five to ten miles off the land, take them in tow, when they would shoot their trawls and be towed at an easy speed all night. The trawls would be hauled up at about midnight, and again about 6 a.m.; the 'Heatherbell' would then go to shore with their fish in baskets, and after it was sold, go off again with the empty baskets to repeat the same operation. This might have continued during the months of July and August, and as it was an exceptional occasion, and almost all the line-fishermen were engaged in the herring fishery, no opposition was offered by them at that time to this proceeding, and the practice was never again repeated to my knowledge.

"Many years afterwards, towage being slack owing to the increased development of screw steamers, several of the paddle-tugs, both on the Tyne and Wear, were fitted with trawls, and worked as trawlers on the inshore fishing-grounds.

"At first they caught a prodigious quantity of fish, and their temporary success was so great that every one was induced to embark in the enterprise. Old tug-boats completely played out, unseaworthy, and unfit for further service as tug-boats, were bought up by persons with no knowledge of the business, and converted into steam trawlers. At first the supply of fish seemed almost inexhaustible, so great was the amount of fish landed, and for a time all went well; but after a year or two of this wholesale destruction the catches gradually diminished, so much so that many of them could no longer find profitable employment.

"This class of paddle-trawlers has gradually died out, there being few remaining at present owing to the fish within a reasonable distance from the land having been exterminated by continual trawling; their large coal consumption rendering them unprofitable for long runs. They have therefore been superseded by screw vessels, specially built for the purpose, and fitted with fish-holds and ice rooms to enable them to keep their fish a considerable time; and as the machinery of a screw vessel is much more compact and more economical in regard to consumption of fuel, they can go a much greater distance from land, and remain much longer at sea.

"These vessels have in their turn almost exterminated the fish on the Dogger and Great Fisher Banks, and several of them this year (1892) have landed their trawl gear, fitted out with lines, and worked at Faröe, &c., at the halibut fishing.

"The extermination of large fish on the inshore grounds has gradually introduced screw steam line-boats. At first paddle-tugs went into the venture, going off from twenty to twenty-five miles from land, and carrying the fish caught on deck; but as fish became fewer, necessitating their going a greater distance into the sea, they in their turn were superseded by screw vessels built for the service, and fitted with fish-holds, &c.

"This class of vessel is largely on the increase, and on the Tyne there is now a fine fleet of steam line-vessels, many of them going a great distance from land, some of them in the herring season catching their own bait, and at other seasons having herring bait sent to them by rail from Yarmouth or Scotland according to where the herring fishery may be.

"It seems as if the steam line-boat will in time supersede the steam-trawler, as they can be of less size and power, consequently less coal consumption; their fishing gear is less costly, the cost of a trawl and rope being from £100 to £150, while a set of lines can be had for about £40.

"A very much better price can also be obtained for line fish than for trawled, only healthy and well-conditioned fish being caught on lines, as sick and spawning fish seldom take bait.

"This steam fishing has of course greatly reduced the number of cobles formerly employed in fishing; at one time there was a fleet of herring cobles at Sunderland, Shields, and Hartlepool, now there will not be more than twenty altogether, the herring fishing being almost entirely done by Penzance, Isle of Man, Scotch, Lowestoft, and Yarmouth vessels, who make the herring fishing a speciality, and follow the herring round the British Isles.

"There are now but very few fishermen in the old sense of the word, that is, where the whole family lived by fishing alone; but there are still a few cobles fishing with lines in winter, and catching crabs and lobsters in summer.

"Of late years mackerel seem to have entirely deserted this coast; at one time they were taken in large quantities by sweeping on the shore, but now they are seldom seen and only a few taken in herring-nets.

"Stake-nets were at one time allowed for salmon fishing, but now they have to be caught by drift-nets only."

PART II.

Chap. I.—The Definition of an Immature Fish.

The term "immature" as applied to fish is somewhat vague, and it is by no means clear that those who originated the complaints about the destruction of fish included in this category, had any very precise idea as to the meaning which they intended it to convey.

If we take what I suppose may be the most ordinary interpretation of the term, viz. "not full grown," we accomplish nothing. In the case of the higher animals, such as quadrupeds and birds, there is a definite limit of size, and after this limit has been reached, in the youth of the organism, no further increase of bulk takes place ; but with fish it is different, since a fish appears to go on growing as long as it lives, a condition which does not admit of the erection of any standard of full growth. The word "undersized" has been frequently used as a synonym of "immature" in connection with fish, but there cannot be said to have been any definite standard of size.

Both words are capable of being used in regard to two very different conceptions, namely, that which has reference to the marketable value of the fish, and that which refers only to its powers of reproduction.

If we regard the terms as referring solely to the maturity of the reproductive organs, we certainly get a definite meaning for them, but at the time when the agitation was commenced there existed absolutely no information as to the size at which fish of various species acquired the power of reproduction. Theories no doubt abounded, and it appeared that many members of the fish trade held the opinion that those fish which were not saleable were immature, in so far as regarded their powers of reproduction. Conversely, it appears to have been generally held that fish large enough to fetch a price were also large enough to breed, or at any rate the affectation of such a belief was not without convenience. Later developments of the agitation have shown that the saleable qualities were really held in paramount importance, very much to the exclusion of any other consideration.

The criterion of market value is of course altogether arbitrary, and differs in different markets and to some extent with the fluctuations of any one market, so that in dealing with the question from the purely biological point of view this criterion may be left out of consideration altogether; but in endeavouring to arrive at a practical solution one is compelled so far as possible to take a view which shall comprehend at once all aspects of the question. A practical solution may be defined, I suppose, as one in accordance with the dictates of common sense,—a quality, by the way, which is usually most strongly claimed by those who have the greatest need of it.

Deferring for the present any attempt at a harmony between the biological and the market standards of maturity, we will at the moment confine ourselves to consideration of the former.

To Dr. Wemyss Fulton belongs the credit of having been the first to endeavour to ascertain the size at which fish of different kinds begin to breed, and, in consequence, to fix a limit of size which would divide the sexually mature from the immature forms. His paper, which is based on material from the east coast of Scotland, will be found in the Eighth Annual Report of the Scotch Fishery Board.

The next contribution to the subject was from my own pen, as the importance of the results obtained by Dr. Fulton suggested to me the advisability of making use of the records of the Royal Dublin Society's Fishery Survey, to continue the work as far as these afforded opportunity. My paper, contained in the 'Scientific Proceedings of the Royal Dublin Society,' vol. iv, pt. vii, followed pretty closely the lines laid down by Dr. Fulton, but introduced a new consideration. Fulton's limit was based upon the size of the smallest mature specimen, without regard to sex. Now it appeared from the writer's remarks, as well as from my own observation, that there was a difference in the sizes at which fish of opposite sexes arrived at maturity, so that a limit based on the smallest mature example of the species must exclude from its benefits many immature forms of that sex which grows to the largest size before beginning to breed. This is, in nearly all cases examined, the female; it is also more plentiful than the male; and it seemed to me that the limit might most usefully be based on the conditions of the larger and more important sex alone. It was evident that, even in one sex, all fish did not become mature at exactly the same size, but I had not sufficient material for the deduction of a satisfactory average, and accordingly fixed the provisional limit at the size of the smallest mature, or nearly mature, female that came under my notice. I was inclined to suspect that further inquiry would show considerable variation of size in relation to locality, a suspicion which has been amply justified.

On entering the service of the Marine Biological Association in

1892, I found myself in a most favourable position for prosecuting the inquiry, since ample supplies of fish could be obtained from the Grimsby market; and in almost all cases I was able to ascertain, with sufficient accuracy, where they had been caught. It must not be supposed that all fish exposed for sale in the market are caught in the North Sea, or even landed at Grimsby, since a certain quantity is sent from distant ports (including Milford Haven), while the Grimsby boats themselves may derive their catches from such widely distant localities as the coast of Iceland or the Bay of Biscay. Still, with the ready assistance of all to whom I made application, I found no difficulty in distinguishing the locality of capture, and, so far as the present question is concerned, I confined my attention to fish caught in the North Sea. Flat-fish were of greater apparent importance than round-fish, so my researches dealt chiefly with the former.

The results of my researches are given at some length in the Association's Journal (N. S., vol. ii, p. 363), but I think it will not be out of place to discuss them briefly in this article.

The question is not altogether so simple as it might appear, owing to two considerations. Firstly, as to fish examined during or in the neighbourhood of the spawning season, there can be, so far as I can see, no means of distinguishing, by mere autopsy, whether a ripe fish is spawning for the first time or not. Secondly, in the case of a fish taken, at any time of the year, with the reproductive organs but little developed, there is a certain difficulty in determining whether that fish has not yet become sexually mature or whether it has reproduced its species (during a previous spawning season or during a previous part of the same year) and is now in what may be termed a "resting" condition, so far as its generative functions are concerned.

Personally I hold the view that, especially in the case of flat-fish, owing to their conformation and the topographical relations of the viscera, it is by no means difficult to arrive at a correct conclusion, when dealing with fish taken at a period remote from the spawning season; while I am not aware of any evidence of the existence of a resting period which covers more than a trivial interval of time. It is within the bounds of possibility that some fish, after becoming ripe, do not develop generative products in every successive season, as hinted by Dr. Fulton; but I do not know of any facts which can be adduced in favour of this view, and prefer to regard occasional instances of very large but apparently immature fish as explicable by the theory of absolute sterility, or great retardation of sexual development.

The considerable degree of variation which one encounters in the assumption of the mature condition within the limits of one district seems to me to be explicable by a condition peculiar, so far as I know, to fishes. We have abundant evidence, thanks to Cunningham's researches, of the great variability of the rate of growth in Teleostean fishes, but all our studies of the life-history of the fish, especially of those forms which show a marked difference of distribution at different stages of growth, seem to show that it is size alone and not age which is the determining factor in distribution. That this should be so is not remarkable, if we accept the hypothesis that it is the quest of suitable food which induces the changes, since a dwarfed individual, however old, would not be likely to require more or different food than its younger but more rapidly developed brethren. I believe there is the same relation between size and sexual maturity to this extent,—that a fish which reaches a certain (approximate) size at the season when the roe or milt commences to ripen, develops in due course into a spawning fish at the next spawning season. But if the fish is a little short of the required standard, its maturation is delayed for another year. During this period its growth does not cease, but is probably all the more rapid because there is no drain on its resources from the generative organs, and so the fish, before it spawns for the first time, has reached a size considerably greater than that of the smallest spawning fish of the species. Probably, in some individuals growth is so retarded that even a moderately large size is never reached, and yet we do not find very small ripe fish (at any rate among the female sex), and I do not see how this can be explained except on some such hypothesis as I have put forward.

In considering the method of distinguishing sexually mature and immature fish at a period remote from the spawning season, or in cases where the roe is only slightly developed, we must consider the changes that this organ goes through in becoming mature. In the immature female the ovary, so soon as it is large enough to be easily perceptible, is found to contain a number of minute translucent ova, their size and condition depending neither on the season of the year nor upon the size of the fish. The first approach to maturity is denoted by an enlargement of some of the ova, and by various changes in their internal structure. The most noticeable of these changes is the formation of yolk matter, since, as has been shown by Mr. Cunningham,* it is that which gives to the ova an opaque appearance which they do not previously possess, and for purposes of convenience I have called the minute translucent ova "inactive," applying the term "active" to those which have become opaque.

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* Mr. Cunningham's paper ('Journ. Marine Biol. Assoc.,' N. S., iii, p. 154) deserves the closest attention in this connection, the more so since, as will appear later, his views differ slightly from my own.

The presence of active ova appears to be a sure sign that maturity is approaching, and, in most cases, that the fish will spawn at the next spawning season. Mr. Cunningham, however, thinks it possible that the yolk appears rather earlier in the sole than in other flat-fish which he has studied, so that more than a year may elapse between the first appearance of the active ova and the first spawning of the fish. I do not think that this interferes with the value of the distinction for macroscopic purposes, since the first appearance of yolk globules is apparent only under the microscope, and I have only observed active ova, with the naked eye, in young soles which might from their size be reasonably expected to spawn during the same year.

In any case the presence of active ova is an infallible sign of approaching maturity, and the further stages of maturation are so obvious as to call for no remark. But when the fish has become fully ripe and has discharged its spawn, the question arises as to how we are to distinguish the empty shotten roe from one which has never developed eggs at all. As a matter of fact the question can usually be settled, in flat-fish, even at a very considerable interval after spawning has taken place, by the presence of more or fewer ripe eggs which have somehow failed to be excluded. These remain either in the cavity of the ovary or in its duct, and gradually decompose there, but the shells remain recognisable for a long period. But without this certain proof of previous spawning, there are characters which appear to me to be in themselves a sufficient distinction. The really immature roe is short, plump, and very firmly fixed between the body-wall and the spines (hæmal) below the backbone, while in a fish which shows evidence of having spawned I have always found the roe wide and flaccid in front, and nearly always extending further backwards along the spines than in the case of an immature roe. It is also comparatively loosely lodged in the position which it occupies. Indeed, if the specimen is fresh, a groove which can be felt by passing the finger along the skin over the roe is almost a sufficient test of the shotten condition, but in a stale fish the groove is more or less perceptible even if the specimen is quite immature.

A recently shotten ovary usually contains a certain number of small active ova, which, as Cunningham holds, are probably absorbed and do not form part of the next season's crop. Then succeeds, in some species at all events, a condition in which all the living ova are in the inactive condition, but no instance has been recorded in which the shotten condition could not be proved by the presence of dead eggs or by other features associated with this condition. Cunningham makes the pertinent inquiry : " are there cases in which, these remains* having been expelled, nothing remains to distinguish a fish that has recovered from spawning from one which has never spawned ?" Personally I do not think there are, for even though, as Cunningham observes, the ovary of a shotten fish may shrink to a very small size, it does not appear, in my own experience at all events, that it ever regains the appearance of immaturity or the close adhesion to the surrounding parts of the body. I must admit that the question is not absolutely judicially proved; still I think the probabilities of the correctness of my own opinion are at least considerable, and, in putting forward the results of my inquiries, have little fear of their substantial accuracy being challenged by subsequent investigators, if only on the ground that the specimens on which my published results were based were examined either during the spawning season or within so short a period from it that traces of maturity, if they existed, could not fail to be detected.

The variation already alluded to in the size at which fish of a species attain to sexual maturity, makes it imperative that any standard of maturity should be based, not on either of the extremes, but on whatever intermediate size appears to apply to the greater number of species. This point was most justly urged by Cunningham, in criticism of the method adopted in my own definition of immature fish on the West Coast of Ireland; but, as I have already remarked, the paucity of material in that case seemed to render the minimum size the safest standard for provisional purposes. Having no lack of material in the North Sea work, I was able to adopt the better method, and the standards given below accordingly represent the sizes at which I believe most females spawn for the first time.

The standard of sexual maturity in North-Sea fish.

Flat-fish.

Turbot . . .	18 inches
Brill . . .	15 ,,
Common sole . .	12 ,,
Plaice . . .	17 ,,
Lemon sole . . .	12 ,,
Common dab . .	7 ,,
Halibut (provisional) . .	36 + ,,

Round-fish.

Cod . . .	25 inches
Haddock . . .	13 ,,
Whiting . . .	9 ,,

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* *I. e.* the remains of ripe eggs.

The turbot and the brill appear to be generally regarded as fish of the same size, but though one occasionally sees a brill which has reached a length equal to that of a very large turbot, there is no doubt that the turbot is, speaking generally, considerably the larger species of the two. The difference is emphasised by that which manifests itself in the sizes at which females of the respective species come to maturity, and in fixing the limit for the turbot at 18 inches I have, if anything, placed it rather too low. I have never seen a fully mature female turbot of less than 18½ inches, but there does not seem to be as much variation in this as in most other species in the assumption of the mature condition.

The smallest mature or nearly mature female sole which has come under my notice measured 10½ inches.

Plaice are rather variable, as I have found an apparently mature female to measure only 13 inches ; but I am certain that the majority of North Sea plaice only commence to spawn when about 17 inches long. I have added considerably to my inquiries since the figures on which I based the standard of 17 inches were published, but the results have only confirmed my previous conclusion.

From time to time I have heard of the occurrence of very small spawning plaice, but it has always chanced that, for some reason or other, the specimen could not be procured for my inspection, nor have I been able to get any details of the actual measurements. I have found it an invariable rule that fishermen and fish merchants considerably under-estimate the length of a flat-fish, so that a statement about a ripe fish of 12 inches would almost certainly refer to one which actually measured at least 14 inches. Nevertheless I am inclined to think that very small spawning plaice are occasionally taken in the North Sea, but that such belong to a very distinct variety. In the Association's Journal (vol. iii, p. 194) I have described a dwarf variety of the plaice which appears to have its head-quarters in the Baltic. The variety first came under my notice on the Grimsby pontoon, whither several consignments were sent in 1894 by a firm of German fish-merchants. The largest fish of the lot only measured 13½ inches, and all were full of roe or milt, the smallest ripe female being only 9½ inches long. The colouration was unfamiliar to me, and I at once formed the opinion that the fish had not been caught in the North Sea, an opinion supported by the presence, among the plaice. of a number of flounders which were very much more spinous than any I had previously seen. I was subsequently informed by the consignors that the whole lot had been caught in the Baltic, where the plaice-like forms are known as "Goldbutt."

On close examination the small plaice were found to comprise a number of forms distinguished from the rest by having ciliated scales, though in some cases the cilia were but little developed; in fact every intermediate condition was represented, and, as it proved on inspection, the ciliation was most thoroughly developed in, and almost confined to, the males. The ciliated examples, known to science since the days of Gottsche, had been considered to be a distinct variety, but it became evident that the distinction was only sexual. The females, not as a rule ciliated, are the "Goldbutt" of Gottsche, and of Baltic fishermen of the present day, who recognise them as quite distinct from the larger North Sea fish which enter the Sound at certain seasons of the year. They are not so distinct in outward appearance from small plaice of the North Sea type as to altogether escape a risk of confusion, but from the fortunate peculiarity of the males we get a knowledge of the distribution of the variety as a whole. The males (formerly regarded as *Pl. platessa*, var. *pseudoflesus*) are stated by Continental naturalists to be commonest in the Baltic and in the Sound, but they have been observed also at Hästholm, and are therefore not altogether unknown in the North Sea. They occur, as I presume, in the eastern fjords of Denmark, and as the Lim Fjord has an opening at either end, there is nothing improbable in their occasional appearance in the North Sea through that channel. Further, Gottsche saw them in the Hamburg market, though that is no proof that they were North Sea specimens, since my own had passed through the Hamburg market before making their appearance at Grimsby.

It will have appeared that there is nothing very improbable in the occasional appearance of a dwarf plaice of the Baltic type in the North Sea, and I believe that any very small spawning fish that have been caught by our boats would have been easily recognised as belonging to the Baltic variety had they come under the notice of a naturalist. At the same time I unhesitatingly assert that the small fish that are caught in such numbers on the Danish and Dutch coasts do not belong to the smaller variety, but are immature members of the North Sea variety. I have examined hundreds of them taken from all parts of the coast, and have never found one of the smaller type amongst them. The possible objection that, the season for the Eastern grounds being later than the spawning season, I may have been deceived in my diagnosis (of maturity or immaturity) by such a reversion to an apparently immature condition as Cunningham appears to think possible, can fortunately be met. Our own boats only fish the Eastern grounds in the late spring and summer, since it is only at that time that there is any certainty of finding a good supply of fish; foreign steam-trawlers, however, sometimes fish there much earlier, and, as they often land their catch at

Grimsby, I have been able in this way to examine the small plaice caught on those grounds during the spawning season, and indeed to compare them with spawning fish consigned at the same time from the Baltic. There can be no possible doubt of the distinctness of the two types, nor of the immaturity of the small fish caught on the Eastern grounds of the North Sea.

The lemon sole or cock sole (*Pl. microcephalus*) agrees with the true sole in that some females are mature at only 10 inches, but I think 12 inches is the length usually attained before the assumption of maturity.

As to the size at which the halibut commences to spawn I have no conclusive information. The fish is not now of much importance in North Sea trawling, on account of its scarcity, and the same reason makes it difficult to procure sufficient material to establish a North Sea standard. Plenty may be had from Iceland or Faröe, but the species reaches a larger size in the higher latitudes, and presumably attains a larger size before spawning than is the case with natives of the North Sea. I think my provisional limit of 36 inches is really considerably below the mark for any district inhabited by this fish.

With regard to cod, the opinion is held by fishermen that there are several distinct varieties within the limits of the North Sea, and in Norway Captain Dannevig holds a similar belief most strongly. I have had neither the leisure nor the inclination to investigate the matter for myself, and consider that, so far as practical purposes are concerned, the existence or non-existence of such varieties is of no moment, as there could be no possibility of discriminating between one and the other unless every fishery official were a trained naturalist. The proposed standard of 25 inches can certainly not be regarded as too high; and, if varieties exist, it is applicable to the smallest. Many cod undoubtedly reach a considerably larger size before spawning.

Before we leave the question of sexual maturity, I must advert briefly to the inquiries on the same subject which were carried on by my colleague Mr. Cunningham, contemporaneously with my own, in the Plymouth district.*

The results are most interesting, since they show conclusively that very great difference may exist in different districts in the size at which sexual maturity is attained by a species. This difference, as Mr. Cunningham justly observes, is a corollary of a difference in the maximum size attained by the species in either district.

Thus the plaice on our South-west Coast are considerably smaller than North Sea forms, and Mr. Cunningham considers the biological

* *Vide* his paper, Journ. Marine Biol. Assoc., vol. iii, p. 64.

limit for the former district to be 15 inches, and has found mature females only 11 inches long.

Lemon soles appear to mature at a very small size on the South-west Coast, as Cunningham records mature females of only 7 inches. These were the smallest he could procure, and none of the fish he examined were immature.

The common sole is usually larger on the South-west Coast than in the North Sea, to judge from consignments which arrive at Grimsby from the district first mentioned, and Cunningham records no mature females of less than 12 inches, while his largest immature specimens measured 13 inches.

As for turbot and brill, there is not sufficient evidence to show that any difference exists as between the two districts, but very few specimens could be obtained for examination at Plymouth.

Having reviewed the evidence as to the definition of sexual immaturity, we must now consider the commercial aspect of the question, and the first definition of the term "immature" of which I am aware was embodied in a resolution by a Conference of those engaged in the East Coast fishing trade, held at Hull in 1890. It was resolved that the term immature fish should be interpreted to mean "a sole which measures less than 10 inches, a turbot or brill which measures less than 12 inches, and a plaice which measures less than 12 inches." This may be taken to represent the North Sea view. It is not wholly a trade interpretation, since plaice and soles of less than 12 inches are saleable; it represents rather a standard of size below which the North Sea trade considered it inexpedient that fish should be destroyed.

However, at the London Conference held under the auspices of the National Sea Fisheries Protection Association in 1892, the trade representation was not confined to the North Sea, but delegates attended from all parts of the United Kingdom, and the standards of size recommended by the East Coast trade by no means recommended themselves to every one. The representatives of the South and South-west Coasts in particular considered the standard a good deal too high, especially in the case of plaice, but with a laudable, though as I think mistaken, desire for harmony, the various parties agreed to a compromise, and the resolution finally adopted by the Conference of 1892 fixed the sizes as follows:

Plaice . . .	10 inches
Soles . . .	10 ,,
Turbot . . .	12 ,,
Brill . . .	12 ,,
Lemon soles . . .	11 ,,

I believe that the result was not entirely satisfactory to either the East or South Coast trade. Unfortunately no attention seems to have been paid to a most sensible amendment, moved by Mr. Mallock, M.P., to the effect that the Conference recognised "the fact that the limitation as to the size of fish in different localities must vary." However, in the above-mentioned resolution we have a definition to which the whole English trade, in so far as it was represented, pledged itself.

The sizes were not altered at any subsequent conference, and were more or less generally supported by the trade before the Parliamentary Committee in 1893. That august body did not, however, see fit to adopt them, considering that the size limit "should approximate to that already adopted by foreign countries," with the result that they recommended a limit of 8 inches for soles and plaice, and a limit of 10 inches for turbot and brill.

It may be useful to recapitulate the different standards:

	Biological limit for North Sea.	Biological limit for Plymouth area.*	Trade limit. Hull Conference, 1890.	Trade limit. London Conference, N.S.F.P.A., 1892.	Select Committee, House of Commons, 1893.
Turbot	18	18	12	12	10
Brill	15	15	12	12	10
Sole	12	12	10	10	8
Plaice	17	13	12	10	8
Lemon sole	12	7	—	11	—

Reference will be made in the last chapter on Proposed Remedial Measures to the probable results of the imposition of these various size limits.

Chap. II.—The Evidence of Deterioration in the North Sea Trade and its Alleged Cause.

a. *The evidence of Deterioration in the North Sea Trade.*

Since my acquaintance with the North Sea trade only dates from the commencement of 1892, it is obviously impossible for me, of my own knowledge, to say what amount of truth there may be in the statements that have been put forward as to the diminution of the fish supply during the last fifty years or so. Much of the evidence that has been at my disposal has been made public by the Parliamentary

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* Mr. Cunningham's figures would appear to yield *averages* approximately as given in this column.

Committee of 1893, and on that evidence, and any other of which I have knowledge, I do not think that one conclusion of the Committee is at all likely to be criticised. It is to the effect that "there seems to be no doubt that a considerable diminution has occurred amongst the more valuable classes of flat-fish, especially among soles and plaice. . . . It is true that there will not be found a great falling off of the bulk of these fish landed on the East Coast. But the appliances for catching them have of recent years been greatly increased in size and efficiency, and the fishing-grounds have been largely extended in area, trawlers going as far as the coast of Iceland to the north, and to the Portuguese coast in the south."

Such evidence as is available consists, therefore, solely of the recollections and impressions of those engaged in the trade, and the last part of the quotation from the 1893 Report illustrates the total inadequacy of the present system of fish statistics. The total quantity of fish landed at any one port may be found in the Board of Trade returns, and, in a good many instances, the different kinds of fish are separately enumerated. But, beyond the fact that the fish were landed at such and such a port, there is no hint as to where they may have been caught. Nor is there any attempt to discriminate between large and small fish. Moreover, several kinds of fish, which, although perhaps of small importance in former years, now represent a considerable item in the profits of a fishery, are not thought worthy of separate enumeration, but are lumped in one column. Thus lemon "soles" and witches, both valuable fish and exclusively products of trawling, are associated with skate, catfish, conger-eels, and a host of others, of which some are largely caught by line-fishing.

Whatever else is neglected, I should say that it was at least essential to distinguish between the products of distinct fisheries at large centres. At the small inshore fishing centres, where everyone takes a hand at whatever kind of fishing is possible, it is of less importance to do so; but the difficulty in any case would hardly arise, since comparatively little inshore trawling is carried on, and drift-net fish are practically confined to two kinds, which are already distinguished in the returns. Fishermen belonging to the large centres are, for the most part, strictly confined to one method of fishing—trawling, line-fishing, drift-netting, or whatever it may be,—and the different branches are so distinct in their interests that no effort should be spared to distinguish them in the returns. I do not know of any difficulty of doing so, provided the staff entrusted with the preparation of the statistics were in any sense adequate to the task; and, except on the theory of want of funds, the existing system courts the criticism of having been devised in some ignorance of the industry with which it is supposed to deal.

The fact is that the fund available for the collection of fishery returns is only £700, and there are 156 collecting stations. I have not the least idea what proportion of the above sum is assigned to each station, but it cannot in the nature of things be otherwise than insignificant in view of the work to be done. The method of collecting the statistics appears to be left entirely to the discretion of the collector. At one port it has been said that the return is merely an estimate of eye. I fancy I am betraying no secrets when I say that at Grimsby the statistician bases his estimate mainly on information furnished by the Railway Company, so that its accuracy depends on the correctness of deductions made for weight of packing materials, additions for difference in condition of fish, home consumption, &c.

Now the fish arrives at the pontoon either whole ("live") or gutted; it may leave the town in almost any condition. It may be sent off *in statu quo*, or may be cleaned, beheaded, boned; only a small part of it may be worth transmission. It may be wet or dried, pickled or smoked; it may come in as a codling, and, or I am much mistaken, go out as a "Finnon" haddock!—be caught as the head of a catfish and the tail of a monk, and go out as the cheek muscles of a skate! The last instance, however, would not affect the correctness of the existing return, as the delicacies in question are assigned to the conglomerate column previously alluded to.

The system will be admitted, I think, to furnish quite adequate opportunities of error, even if the emoluments were sufficient to allow of one man's devoting his whole attention to the production of an accurate return, which I am far from supposing to be the case.

Accuracy in returns, I imagine, can only be ensured by counting the quantity of fish landed on the pontoon, and as the quantity is very large and the time during which the fish are undisturbed is but short, this duty could certainly not be satisfactorily undertaken by one man alone, even were his attention free from any private business of his own. This system would permit of the complete discrimination between line and trawl fish, and between fish from the North Sea and those taken at Iceland, Faröe, &c. According to the experience of the statisticians, a certain amount of discrimination would be possible even between fish from different parts of the North Sea; at all events it would be possible in great measure, from the peculiarities of colouration in the flat-fish, to check the accuracy of answers which might be given to inquiries as to place of capture, and of course there would be no longer any difficulty in discriminating between large and small fish. Statistics dealing merely with weight, without regard to size, are altogether misleading. There is no difference in the weight of a box of fair average-sized plaice and a box of small ones; but the former contains only about 100, and the latter may contain about 250, as is commonly the case at Grimsby, or as many as 1036, as in an instance reported from Billingsgate. The hopeless impossibility of obtaining a correct idea of the fishery from statistics which do not distinguish between such boxes requires no argument.

There is a further method of statistical inquiry, which, if it were available, could be utilised by the statisticians as a valuable check on the accuracy of their own numerical observations, and would furnish in addition the most reliable information of value. The auctioneer furnishes to the smack-owner an account of fish sold, in which the separate kinds and the quantities (usually also, I believe, the quality in regard to size) are enumerated, and a copy of this is handed, at least by some owners or companies, to the skipper, who has an interest in the distribution of the profits. There might be an objection to a copy being handed also to the local statistician, but I do not see that there could be any legitimate objection to the information being supplied to the central statistical authority. It is conceivable, nevertheless, that serious opposition, not wholly unconnected with considerations of income-tax, might be offered, in which case it would be better, perhaps, to make each skipper furnish a return only of the quantity of fish landed, in boxes or other local measurements. If this were done, the duties of the statistician would be lightened, and one man would probably suffice to ensure that the skippers' returns were more or less accurate.

The skipper should be required, I think, to state whereabouts he had been fishing, but it would be a hardship to make him give detailed information; and if he had a good catch from some ground not generally known to be productive at the time, such information as he vouchsafed would probably be worthless. Some check on the value of this latter class of information might be derived from the fishery cruisers, were the latter to keep a diary of fishing-vessels sighted (if they ever do see any), and furnish weekly lists to the ports to which the vessels belonged. Accurate account should be kept of vessels entering and leaving the port, whether belonging to it or not, so that in computing the result of the fishery it would be possible to check the amount of fish caught by the amount (in voyages) of fishing power expended; and in this, as in other details, it would of course be essential to distinguish between trawlers, codmen, &c.

The Parliamentary Committee expressed themselves in their report as "strongly of opinion that any steps which may be taken to increase the trustworthy character and fulness of official statistics would amply repay the expenditure which may be necessary to ensure the improvement;" and it is to be most sincerely hoped that the authorities may see their way to give effect to this recommendation. I have endeavoured above to formulate suggestions for what appear to be the most urgently required improvements in the existing system of returns. Though based upon the conditions of the Grimsby industry, it is probable that they are equally applicable to all fishing centres, and they may be briefly recapitulated as follows:

1. An absolute separation of the products of different methods of fishing.

2. An exact account of the expenditure of fishing power in each branch.

3. Discrimination as between large and small fish of a species.

4. A more complete separation of species (so that lemon soles, witches, &c., may be separately enumerated).

5. Discrimination, as complete as may be practicable, of the locality of capture.

I have made no mention of meteorological information, since I do not think there is any necessity for the Fisheries Department to go to any expense in collecting statistics of this kind at first hand, but the ample information available to every one from the Meteorological Office should certainly be carefully considered in the preparation of fishery returns. The weather is known to have the most important bearing on fishery operations, not only at the time of incidence, but often in the succeeding season; and the remarks "As to the weather, &c.," in the "Summary of the Returns made by collectors of Fishery Statistics," if based on the most profound examination of meteorological phenomena, bear no intrinsic evidence of the fact.

It is hardly necessary to say that the preparation of returns so complete as those which I recommend calls for no mean degree of intelligence on the part of the collector; and intelligence, like any other commodity, has to be paid for. I think it is essential, too, that the official in charge of the whole system of fishery returns should be skilled not only in the commercial, but also in the biological aspect of the fisheries. Such knowledge would enable him to grasp at once the probable importance of any development indicated in the monthly returns of his subordinates, and, if a reserve fund were at his disposal, to institute whatever subsidiary inquiries the case might appear to call for.

Without a system of statistics at least as complete as the above, I do not see that one can acquire even an approximate idea of the state of the fishery for the current year, nor would a long series of incomplete returns yield any reliable ground of conclusion at a future time.

B. *The Alleged Cause of Deterioration in the North Sea Trade.*

The diminution of the fish supply being admitted, it remains to consider what evidence there is as to the means whereby it has been brought about. Such deterioration has been admitted unreservedly only in the case of the North Sea, and there in the case of flat fishes alone.

From the southern fishing centres even of the North Sea there is not an unanimous admission of a decrease in the general supply, but the scarcity of large fish is acknowledged. Having little personal knowledge of the Yarmouth and Lowestoft fishery, in so far as it differs from that of Hull and Grimsby, I must leave my readers to form their own conclusions from the evidence offered to the Parliamentary Committee from those ports.

The alleged cause of the North Sea decrease is over-fishing,—that is to say, over-trawling. Especially is it attributed to the operations of the large deep-sea trawlers. There exists, it is true, or did exist, a subsidiary outcry on the part of longshore line-fishermen, crabbers, &c., against the practices of inshore trawlers, whether of large or small tonnage; but this grievance was of local importance only, and could not be said to affect the industry as a whole to any appreciable extent. Therefore, though inshore matters call for a share of our attention in due season, we may for the present devote ourselves to the deep-sea question.

The decrease in the returns of this branch of the industry were, and are, essentially attributed to the destruction of large quantities of small fish, and the bulk of this destruction is generally known to occur on grounds lying along the Dutch, German, and Danish coasts.

A glance at the chart appended to this paper shows that a line drawn from the Spurn to Hantsholm, in Jutland, forms a rough division between the deeper and the shallower parts of the North Sea. Eastward of the longitude of the Great Silver Pit and south of that line the water never attains a depth of 30 fathoms. North of the line, water of less than 20 fathoms is pretty well confined to a narrow fringe along the British coast, the Dogger Bank, and a stretch of ground that follows the course of the line from the tail of the Dogger to the entrance of the Kattegat. It is also apparent that on the eastern side the shallow soundings run very much further out than on our own coast. The Continental coast forms a large bight, of which the estuaries of the Elbe and Weser are the head; while the limbs consist of the coast of Schleswig-Holstein and Denmark to the north, and of Hanover and Holland to the south-west: along both these limbs is seen a series of barrier islands, separating the open sea from large shallow expanses of which a great part dries at low tide; the embouchures of numerous streams, large and small, give on to these areas.

At the present day our trawlers cannot afford altogether to despise the territorial rights of the various powers which own this stretch of coast, and the fishing grounds affected by Grimsby vessels are accordingly at a respectful distance outside the chain of islands. The westernmost is off Terschelling light, in about 12 or 15 fathoms, but in an easterly direction boats approach the shore more nearly, fishing along the islands of "Skimliko" (Schiermonnikoog), Borkum, Norderney, &c. Everywhere the ground is smooth, except for a "rough" on Borkum Flat. Trawling is also carried on about the "Island" (Heligoland), and northwards from the island last mentioned to the Horn Reef, this ground being collectively termed "above the Reef," while special parts of it are spoken of according to the name of the nearest island. "Below the Reef" the grounds extend as far north as the Holmen light. A line of rough, boulder-covered ground, supposed to be the moraine of some glacier, follows the general course of the Danish coast approximately in the manner indicated on the chart, and the trawling grounds are anywhere between this and the coast, but, for small fish, as close in as the boats can venture. I do not know that it is necessary to describe the grounds in greater detail here, as this does not profess to be a fisherman's itinerary of the North Sea; nor, be it remarked, do I recommend the use of the chart for the more exact purposes of navigation. It will serve, however, as I hope, to illustrate the remarks which I have to make on the destruction of fish on various grounds; but, before proceeding directly to this subject, it may be as well to review what is known of the life-history of some of the fishes on which the trawling industry depends. Some comprehension of this is absolutely essential for a due appreciation of any fishery question, and especially of one into which the destruction of young fish enters largely.

Chap. III.—The Life-History of North Sea Food Fishes.

While we remain in ignorance of far too many facts in the life-history of even some of the commonest food fishes, we have been able to form at least a tolerably clear idea of the breeding habits of many of them, of their appearance in the infantile condition, and of their haunts at different periods of existence; and in the consideration of questions affecting the over-destruction of young fish these facts have to be constantly borne in mind.

There appears to exist, in many persons who express opinions on fishery matters, a lamentable tendency towards generalisation. The fish form an enormous class, composed of species and families, of which some are so far distinguished from others, not only in conformation but in habit, that it is hardly possible to say that they have much in common beyond that they live in the sea, and breathe by gills. Yet the amateur exponent seems mentally to assign to the most widely distinct kinds a degree of relationship which he would probably be loth to admit as existing between himself and his next-door neighbour.

As a matter of fact, every species of fish requires separate consideration, or at the most, only a few kinds can be grouped together, and that only in relation to a part of their life-history and habit, and not to the whole. It will, perhaps, be no waste of space if, before entering on the question of their destruction, I endeavour to sketch briefly the facts that are known with regard to the life-history of some of the more important kinds.*

Even in dealing with fish of one kind one cannot make sweeping conclusions with regard to locality, since a species often differs considerably in habit, at distances so little remote as are the opposite coasts of this country. There is little or no difference in the temperature in such cases, but there may be a great deal of difference in the coast itself and the soundings at sea. Thus on the west of Ireland we have a very bold coast, rocky in most places, and everywhere with deep water at no great distance from land. One may literally step from land into 40 fathoms of water, and fish in 80 fathoms in sight of some outlying island. For a great part of the coast-line the territorial limit is not far from coincident with the 40-fathom line. When we turn to the North Sea, we find that part of the area with which we have most to do almost entirely devoid of rocks, and everywhere comparatively shallow. Indeed, south of the Fisher Bank the maximum depth is about 60 fathoms, and that is found only in a very limited part.†

Yet much the same kinds of fish occur in the two districts, and, of course, their habits, in adaptation to the available physical conditions, show corresponding modifications. So far as there is constancy of habit in relation to physical conditions, it is found to be related to depth of water, and, of course, to nature of bottom. Proximity to land is of comparatively little consequence (though an isolated bank does not correspond, faunistically, with similar soundings not separated from the coast by intervening deep water), yet one is tempted to think that many prefer to obtain their ideas of the sea from a study of the map rather than the chart.

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* In explanation of the terms used in this chapter, it may be said that some fish deposit their spawn on the bottom; it is then termed "demersal." In the case of other fish, the spawn floats to the top of the water, and is then called "pelagic." When first hatched the little fish or "larvæ" appear to be always "pelagic," *i. e.* swimming at the surface; in the case of flat-fish the pelagic larva undergoes a "metamorphosis" or change of shape into the flattened form, at or near the time when it adopts the habits of adult fish by sinking to the bottom.

† See chart at the end of this paper.

The west coast of Ireland and the North Sea present the greatest contrast which is to be found within the limits of our own seas, but minor physical differences exist between all our districts, such as the Channel and the Irish Sea, involving correspondingly minor divergences in the habit of the fish which are found there. As we are dealing with the North Sea, my remarks must be understood to refer to that area.

With regard to the **breeding** of fish we may make one tolerably sweeping generalisation—viz. that, with the exception of skates, herring, and cat-fish (or wolf-fish), all our food-fish propagate by means of eggs which float singly at the surface of the water, at least for some considerable part of the time during which the embryo is developing. Of the more valuable* kinds, all the eggs float up to the actual time of hatching, except in the case of the turbot, the eggs of which seem always to sink some days before hatching takes place.

The **turbot**, though not a very abundant fish, is distributed pretty well all over the North Sea trawling grounds, though scarce in the deeper parts, such as the deep water north of the Dogger, and on the Fisher Bank. Being a predaceous form, feeding largely on herrings, it appears to be somewhat given to migrating in pursuit of these fish, and occurs occasionally in considerable numbers on grounds where it is usually by no means plentiful. It is most abundant probably on the Continental coast, where a good many are always caught in company with the small plaice. Spawning, which is carried on chiefly from the latter part of May to the end of July and later, does not occur, so far as I know, very close to our own coast, but rather on the offshore grounds. On the Continental side, however, spawning fish may be found in comparatively shallow water and fairly close inshore,—in fact, on the small fish grounds. I do not know that the eggs have ever been recognised from tow-net gatherings, but very young specimens, from about one fifth to three fifths of an inch, have been found swimming at the surface of the water a few miles off the coast of Denmark, and on the west end of the Dogger Bank in July and August. I have not found the immediately succeeding stages in the North Sea, but young turbot of about an inch and a little larger have been found by Mr. Cunningham, still at the surface, in Plymouth Sound, and I have no doubt that in the North Sea also these fish approach the shore towards the end of their period of pelagic life. I know of no instance of these very young turbot being taken anywhere but at the surface, but shortly after the adult form has been assumed they evidently descend to the bottom.

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* The egg of the gurnard may, but does not invariably, sink some time before hatching. I do not know any other instance, unless the weever can be called a food-fish.

Exactly where they pass the first winter of their life remains yet to be discovered, but it is almost certainly in comparatively shallow water and at no great distance from land. From the first warm weather of spring throughout the summer young turbot of the previous season's brood, measuring about 3 to 5 inches, are found sparingly among the shrimps and small plaice at the extreme margin of the Humber estuary, and elsewhere along the sandy beaches of our own coast. I have taken them myself at St. Andrews, Filey, and Cromer, and have no doubt they are generally distributed along the east coast. The number taken is nowhere large as compared with the young of other species, but it must be remembered that the turbot, nowadays at any rate, is far from abundant at any stage of existence on our own coasts. I have never heard of such young fish being met with anywhere but at the margin or near it, and do not believe that they range at all into deep water until a larger size has been attained. I have had no opportunity of acquainting myself with the haunts of fish at the corresponding stages on the Continental coast, but have been informed that they are common in the spring and summer and in the large shallow sandy expanses about and within the barrier chain of islands on the Dutch and Danish coasts, and have no doubt of the correctness of the information.*

Larger, but not necessarily older fish, are also found in quite shallow water, close inshore, on both coasts, but much more abundantly on the eastern side of the North Sea. There appears to be a gradual removal from the immediate vicinity of the margin as the size increases, but I do not find many fish under twelve inches in length, outside that area which the moderate degree of respect shown by our trawlers to territorial rights leaves comparatively unmolested. On our own coast similar fish seem to be almost, if not entirely, confined to estuaries or inshore grounds. I have paid but little attention to the probable ages of these small turbot, since, as I have previously remarked, the distribution does vary with the size, and cannot be proved to do so with the age of the fish. The former is a matter of fact, the latter one of opinion only, and, in my humble opinion, not a matter of the highest importance in practical fishery problems, except in such cases as the artificial propagation of fish and the temporary closing of defined areas.

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* Note added in press. Much valuable information as to the life-history of turbot and other flat-fish in the Cattegat, &c., will be found in Dr. Petersen's Report on the Danish Biological Station for 1893 (1894).

Larger turbot, from about 12 inches up to any size which the species attains, are found in great abundance throughout the spring and summer on the whole of the Eastern grounds ; opportunities of ascertaining whether they are in the same locality at other seasons of the year are rare, but I have known a considerable number, mostly of the smaller sizes, to be taken very early in the year, before the plaice had appeared in any number, and again in the autumn, after the plaice had mostly departed elsewhere. I have already said that many turbot spawn on these grounds.

The young fish do not appear to betake themselves to the offshore and deeper parts until a length of at least about 14 or 15 inches has been reached, and many certainly stay inshore until later. An examination of the total catch from all parts of the North Sea prior to the opening of the season for small plaice affords a very fair means of judging what proportion of small fish may be present on the offshore grounds.

I have found that the percentage under 17 inches does not exceed 30 per cent. ; even this is somewhat unnaturally high, since a good many of the small fish were contributed by a shallow ground on our own coast, but of the whole number of small fish the bulk would be males, sexually mature, since the male may begin to breed at only 12 inches.

In its habits, distribution, and life-history there is little to be said about the **brill** which has not already been said about its more valuable relative, the turbot. The brill spawns earlier than the turbot, viz. from the beginning of May, or earlier, until the end of July, but the spawning takes place in the same localities for both species, and, of course, the periods are partly coincident. The smaller free-swimming larvæ, when changing to the adult condition, have not yet been recognised with certainty, but the stages just prior to the assumption of the adult form have been met with by Mr. Cunningham at Plymouth in the same locality as the corresponding stages of the turbot. All the evidence we have shows that the subsequent life-history is identical in the two species. Brill seem to be more abundant on our own coast, turbot being in the majority on the Continental coast. In their distribution with regard to size, the two forms seem to agree pretty closely on the Eastern grounds, but as the brill matures at a smaller size, it follows that the proportion of sexually immature fish on the trawling grounds is rather lower. Indeed, I have usually found the proportion of immature brill in the catches on Eastern grounds to be a very small one; but it varies considerably, since occasionally a very marked number of sexually immature forms will be taken. Many immature fish are sometimes caught on a shallow ground near Mablethorpe in Lincolnshire. On the offshore grounds in any part of the North Sea comparatively few immature fish seem to occur.

The distribution of the **sole** in the North Sea is so far capable of more or less exact definition, in that there is a large area in which soles are at all events very scarce. The species is very rare in Scotch waters, but occurs more plentifully southwards along the east coast of England. It is found also on the grounds lying off the coast of Denmark, and southwards along the Continental margin, also in the central parts of the North Sea, south of a line which may be drawn across so as to follow the southern edge of the Dogger Bank. Thus the Dogger and all the central area of the North Sea northwards of this bank may be eliminated as practically devoid of soles. None are found, I believe, on the coast of Norway, and, indeed, the channel of very deep water which follows the Norwegian coast-line seems to act as a boundary impassable to all but the bathybial* flat-fish. That it should be so by the adults is intelligible enough, but it is not so clear why the pelagic ova and larvæ should not cross it. That they do not do so to any appreciable extent is rendered extremely probable by the marked structural differences which one finds to exist between the Norwegian turbot and their brethren of the North Sea.

The sole spawns in the North Sea chiefly in May and June, though the whole period may extend from April to August. Spawning on our own coasts takes place chiefly on the offshore grounds, always in water of some depth, and away from the chief haunts of young flat-fish; but on the Eastern side a great deal of spawning is done on the small-fish grounds. Of the very young stages I know but little from my own observations, having only obtained a few recently hatched larvæ in the tow-nets. The later metamorphosing stages I have never found, either in the North Sea or elsewhere, but specimens of about half an inch long have been found by Mr. Cunningham between tide-marks in Mevagissey Harbour. Soles of about an inch and a half in length begin to appear in the Humber in the summer, though not to my knowledge at the extreme margin, but specimens from about two and a half to four inches are not infrequent at the margin from spring to autumn, and occur also, as I understand, in similar situations further south along the Lincolnshire coast. I do not know that there is any record of the occurrence of such small forms anywhere except close inshore, either in shallow sandy grounds or in estuaries; and for my own part I believe that, while the early stages of metamorphosis are pelagic, the young fish, on the assumption of the adult conformation, adopt an inshore or estuarine habitat, and are in no sense generally distributed over the North Sea. There is no evidence of such general distribution, though it is commonly asserted by fishermen that they catch large numbers of very small soles on the grounds about the Well Bank, and also on the Eastern grounds; but all the small examples which I have obtained from either locality have proved to be solenettes (*S. lutea*). The solenette is very easily distinguished from a true sole of the same size if the two are compared together, but this the deep-sea fisherman has no chance of doing, as he never catches any very small true soles.

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* The halibut, witch, and megrim are the only North Sea flat-fish of any importance which regularly descend to great depths, and are thus "bathybial" in habit.

Soles of all sizes, from about five to about twelve inches, are fairly plentiful in the Humber during the spring and summer, especially on certain grounds, mostly with rather deep soundings; but occasionally examples of larger size than those previously mentioned are taken at the margin also. About the beginning of July larger fish, which have recently spawned, begin to make their appearance in the river, but most of them disappear again by November. In the autumn a considerable number of fish, all of fair or large size, arrive in Scarborough Bay.

Of the haunts of very small soles on the Continental side I know little, but have been told that in the early days of trawling, when the smacks used to tow almost up to the beach, great numbers used to be caught of a size much smaller than those which are now to be found beyond the three-mile limit, and I have no doubt that the shallow sea lakes of Holland, Germany, and Denmark are the nurseries of the species for those coasts.

From any absolute knowledge which we have of the distribution at different sizes it appears that the sole, after the completion of its early metamorphosis, becomes practically an estuarine or, at least, an exclusively littoral species until it has reached a size which closely corresponds with that at which sexual maturity is assumed.

Of the winter habitat of young soles it is hard to speak positively, since very few can be obtained anywhere. To a certain extent they may migrate into deeper water, but I know no proof of this, and I am inclined to share the belief of many fishermen that they hibernate to a great extent by burying themselves in the sand; their powers of burrowing must be well known to every one who has watched them in captivity.

It is well known that the former abundance of soles in the

Silver Pits was a phenomenon confined to the winter, and, as I am given to understand, soles were always most plentiful there in very hard weather. Within recent years the fish taken from the Pits consist, according to my observations, chiefly of mature fish; at any rate, I have seen no very small ones. I have been told, however, that small soles used to be plentiful there; but the information, based upon recollections of a fact which, at the time of its occurrence, no doubt seemed unimportant, cannot be considered as wholly reliable. The Great Silver Pit is about equidistant from the summer sole grounds of either coast of the North Sea, and its winter supply is recruited, I should imagine, from both coasts. A violent gale sometimes has the effect of driving soles into deeper water; thus after the great gale of November, 1893, there were good takes of these fish in the Yorkshire Hole or Little Silver Pit, where none had previously been obtainable.

Our knowledge of the life-history of the **plaice**, certainly the most important, if by no means the most valuable, of trawl flat-fish, is fortunately fairly complete. In the adult condition the species is generally distributed all over the North Sea, but is not found very close inshore, or in very shallow water on either coast. It is the earliest spawner among the fish with which we have to deal here, breeding chiefly from the middle of January to the end of March; to some extent a little later, and probably earlier also. There is at the spawning season a distinct congregation of mature fish on different grounds well known to the fishermen, such as various parts of the Dogger, and a ground lying about fifteen miles off Flamborough Head, &c.; but none of these grounds are very close inshore, nor, so far as I have been able to discover, does any spawning at all take place on the shallow sandy grounds on the eastern side of the North Sea. The plaice, in fact, is in the North Sea distinctly an offshore spawner, and, as far as its mature condition is concerned, practically an offshore fish altogether. The eggs are pelagic,—that is to say, they float at the surface; but this fact is not universally appreciated, even by the more enlightened members of the fishing community. There is a substance which some deep-sea fishermen regard as plaice-spawn; what it is I do not know, as I have never been able to inspect any of it, and as the description given of it is only sufficiently exact to render it perfectly certain that the describers' diagnosis is incorrect. It is said to be yellowish in colour, and may possibly be the spawn of the little sucker or gobbler (*Liparis* sp.). Of this I have obtained a good deal on and from grounds which are frequented by spawning plaice, but have not had an opportunity of showing it to any of the exponents of the demersal theory of plaice ova. The inshore fishermen regard quite a distinct organism as the spawn of plaice, as we shall see later on.

The general set of the tides or currents in the North Sea is well known to be towards the Heligoland Bight, whither most floating wreckage ultimately finds its way, and it seems natural to suppose that the floating eggs of the plaice liberated in the open sea, to a great extent, drift in that direction; the same must be the case with the younger and more helpless of the larvæ. I am far from supposing, however, that the current is by any means the sole determining factor in the distribution of the very young forms, since we do not find on the eastern side the young of several species which must, in their earliest condition, have been exposed to exactly the same tidal influences as the plaice.

In any case the very youngest free stages of the fish do not seem to occur very close inshore on either side of the sea, and most of the phases of the metamorphosis appear to be passed at some little distance from land, or at least in tolerably deep water. The small transparent forms, though capable, like the young turbot, &c., of swimming at the surface, appear to be commoner at the bottom; at least I have found them so, but my fishing operations have very seldom been favoured with that calm, warm weather which appears to have the greatest effect in bringing young flat-fish to the surface.

By the time the young fish has acquired the adult form, a process which is accomplished some time in the late spring or early summer, it will be found, on any coast with which I am acquainted, at the extreme margin, either on the open sandy beach or in an estuary, in company with shrimps and a certain but much smaller number of dabs, sole, turbot, &c. The little plaice is now about an inch long, and from that size up to about three inches the young fish remain very close to the beach throughout the warmer parts of the year. Indeed, it seems probable that those which fail to reach a larger size before the winter remain in the same situation throughout that season. Some at least are obtainable there at the coldest season, and I have found none elsewhere. Possibly they bury themselves to some extent in the sand or mud, but I do not think that they go out to sea, though they may possibly move into rather deeper parts of an estuary than they frequent in summer.

As the size increases there is a gradual withdrawal from the immediate neighbourhood of the margin; thus, in the Humber, there are only a few fish, comparatively speaking, at the margin which exceed a length of about 4 inches, while in the deeper parts there are not very many fish of less than 4 inches. Plaice do not frequent the deepest parts of the Humber to any great extent, but in moderate depths, from two to six fathoms, one meets with all sizes from about 4 inches up to 12, and in less numbers up to 14 inches. Larger fish are extremely scarce there; indeed, I only know of a solitary instance of the occurrence of a 17-inch plaice in the estuary. The same restriction of size applies to the shallow sandy inshore water of our own coast, whether estuarine or not, and on the vast shallow expanses of the Continental coast the great majority of the plaice do not exceed a length of 13 inches. On the Terschelling fishing ground, where the boats do not go very close inshore, I do not think there are many fish of less than 8 inches, but further north our vessels get a great many from only 4 inches upwards. There is always a certain proportion, not a large one by any means, of fish up to about 15 inches on these Eastern grounds, with occasionally a very much smaller number of large fish; and large fish are found on certain rough patches quite close to the small-fish grounds.

The small fish are plentiful on the grounds from some time in March, if the spring is forward, until the autumn, and a bright calm day in winter is said to bring them out, while heavy weather from the south-west will cause them to disappear. Trawlers imagine, I know not with what reason, that they emerge from and retreat to the "lakes" inside the barrier islands; also that they bury themselves. The former theory, at all events, is very probably in accordance with facts.

So far we have seen the young plaice, after the completion of its larval metamorphosis, confined to an immediately littoral or estuarine habitat. It remains to be seen at what period they pass into the open sea, or into the more central regions thereof. On our own coast there is no obvious migration, but as the fish are never found in the river or bay beyond a certain size, it may be supposed that in the autumn the larger representatives pass out to sea, never to return; and it may be noted that there is a certain correspondence between the size at which they leave the river and that at which the first symptoms of approaching maturity begin to manifest themselves, though some proportion, I imagine, must spend another year on the offshore grounds before their reproductive organs begin to mature.

On the Continental coast, where the numbers of small fish are very much larger than on our own, there is a most definite migration seawards, and every autumn our trawlers are certain of finding a great catch of plaice between the Dogger and the Eastern grounds. The fish are small, but their sizes correspond to those of the *largest* of the fish on the adjacent inshore grounds, none of the very small ones being present. There can be no doubt, I think, that they are the largest of the brood making their first journey to the haunts of their parents. Once they reach the Dogger, they soon scatter; but they can be traced through the later months in the considerable proportion of small fish which are found among the large ones on that ground in winter, and when the spawning season arrives no doubt some at least are mature.

We see thus that up to a length of about 12 or 15 inches the North Sea plaice is inshore or estuarine in habitat; beyond that the species, nowadays at least, is practically confined to offshore grounds.

I spoke just now of a theory held by longshore fishermen of the reproduction of the plaice. These men are, or affect to be, totally unable to appreciate the fact that a fish may differ in its distribution at different ages or sizes, and maintain that the plaice which they get in their bays or estuaries are a distinct race, to which they apply the names of "flat-fish" or "fluke," using them in the specific and not the commoner generic sense. The same contention is held on the Lancashire coast, in the Humber, and, as may be learned from the minutes of evidence before the Parliamentary Committee, further down the Lincolnshire coast. The fishermen's arguments are various, not to say contradictory. The chief argument is that they never get these flat-fish as large as an offshore plaice, which, of course, is not remarkable. A most curious point sometimes urged in favour of the theory is that the "flat-fish" never have a roe in them. How they maintain their numbers without the use of a roe is not explained. It is true that in answer to a question on the subject, a fisherman from Skegness (Minutes of Evidence, 5041) said that ripe spawn was found in them in May and June. I take leave to suppose that this fact was "wrenched from his imagination;" and, indeed, the mental process by which it was arrived at becomes perfectly evident from the rest of his answer, viz. that after these months, in July, August, and September, there are multitudes of "flat-fish" of one, two, and three inches. Threatened with the imposition of a size limit for plaice, it is obviously in the interest of longshore trawlers and shrimpers to maintain the specific distinctness of the "flat-fish."

Though most acknowledge, and all, I suppose, must be aware that spawn is never found in these small fish, there is no lack of information, of a kind, as to their life-history. On the sandy stretches between tide-marks in spring and summer one finds a number of gelatinous greenish or brownish capsules, attached to the sand by the insertion of a long filament. These things, which are well known to naturalists as the spawn of a marine worm, are strenuously asserted by the longshore fishermen to be that of their "flat-fish." No attempt, however, is made to dispose of the interval between the unhatched spawn and the fully metamorphosed little plaice of an inch long, nor to trace the spawn to the reproductive organs of the parent. How much of this theory is actually believed, and how much is assumed in order to humbug people whom the shrimper believes to be in the almost unattainable position of knowing less about fish than he does himself, it is impossible to say. As long as it can be used as an argument against interfering with his pursuits it will probably flourish.

I have already explained (*supra*, p. 378) that the actual existence of a dwarf variety of plaice in the Baltic, and to some extent on the North Sea coast of Denmark, may have probably given rise to opinions that the small plaice on the Eastern grounds do not grow larger, but that the plaice which are found on these grounds belong to the ordinary North Sea type, and are simply young specimens thereof.

The **lemon sole** is found in most parts of the North Sea, both on deep and shallow grounds, but occurs nowhere in very large numbers, and is certainly far from plentiful on the Eastern side—at least, large numbers are not caught together; but, as the fish has a decided partially for "roughs," it may possibly be plentiful on rocky ground quite inaccessible to the trawler. It is not, however, by any means confined to rough ground, being found in fair numbers on the sandy expanse of the Fisher Bank and on perfectly smooth ground elsewhere. The spawning period is protracted, extending from April to September, and spawning does not take place in shallow water. Very little is known of the life-history. Previous to 1893 young fish of less than about 6 inches were hardly known, the only specimens accounted for being a few of 2 and 4½ inches taken on the Smith Bank in the Moray Firth, at 20 fathoms, and two incompletely metamorphosed examples of less than 2 inches which I recorded from 62 to 80 fathoms on the west coast of Ireland. It was obvious that the corresponding stages could not be passed at the same depths in the North Sea—*il n'y en avait pas de quoi*, but I supposed that at least the young fish were confined to considerable depths. I was therefore a good deal surprised to find the species occurring in some numbers in the Humber from a length of 2 to about 4 inches, and, more sparingly, upwards to 11 inches. They were never at the immediate margin, like the very young plaice, but in rather deeper water. A certain number of these very small lemon soles appear to remain in the river throughout the year, and I do not know anywhere else that they occur. I have no knowledge of the occurrence of small lemon soles on the Eastern grounds.

Of the distribution of the **common dab** and its life-history, it is sufficient to say that it is found everywhere and at all stages in every part of the North Sea, both inshore and offshore, and that, except in estuaries, it seems to spawn anywhere without regard to depth of water or proximity to land. It may be added that it appears to eat anything which it can get into its mouth, a faculty which probably accounts for its universal distribution. Large dabs occur on the eastern grounds in sufficient numbers to be worth bringing to market.

The **megrim** is rare in the North Sea, being almost confined to the deepest grounds. The **witch** is much more plentiful, but confined to the deeper grounds. Immature members of either species are never found on inshore grounds, nor do I know any ground on which they can be obtained.

The **flounder** is chiefly an estuarine fish, and, with the exception of the Eastern grounds, occurs on no ground worked by deep-sea trawlers, except at the spawning season.

Spawning takes place at sea, but the young find their way at a very early age into shallow bays, near the mouths of rivers, and into estuaries, rivers, brooks, and even ditches, the species being quite at home in perfectly fresh water. These localities are not quitted until the fish is ready to spawn, and spawning having been accomplished, the former haunts are at once regained.

The **long rough dab** is almost exclusively an offshore fish, especially in its younger condition. It has no commercial value, and is not considered by Grimsby trawlers to be fit for human food.

The **halibut** is very far from plentiful on North Sea trawling grounds. Practically nothing is known of the early stages of its life-history. A few immature specimens of considerable size are sometimes met with on the Eastern grounds, but are not much commoner there than on offshore grounds.

The **sand sole** and **thickback**, of which the latter is of some importance to south coast trawlers, do not occur, to my knowledge, on any North Sea ground. Thickbacks are obtained on the Bay of Biscay grounds to which North Sea steam-trawlers occasionally resort. The young stages, as far as our meagre information goes, are found in very deep water, and the species is at no stage to be found on inshore grounds in northern latitudes.

Round-fish.—Very young cod approach quite close to the shore, and enter estuaries in very considerable numbers, but the number of those which pass all stages of their existence in the open sea appears to be at least as large. Very young whiting frequent estuaries in enormous numbers, but fish of the same size are plentiful also on offshore grounds, so that the immature members of both these species cannot be said to be restricted to either inshore or offshore grounds. The haddock is more exclusive. It appears to avoid estuaries altogether,* though both mature and half-grown fish may approach the coast where no considerable fresh-water outlet exists. The very young stages (having the adult conformation) have only been met with on offshore grounds. I am not aware that very small haddock ever occur on the Eastern grounds.

It will be seen from the foregoing remarks that we can generalise but little with regard to the distribution of mature and immature trawl fish. We can say that the plaice is an estuarine or inshore fish in its immature condition, and practically an exclusively offshore fish when mature. Soles, turbot, and brill are inshore fish and estuarine fish when immature, but to some considerable extent are inshore spawners also, *i.e.* on the Eastern grounds, while the plaice is not. Haddock, as far as we are here concerned, may be considered as exclusively offshore fish.

Chap. IV.—An Examination, with Statistics, of the Destruction of Immature Fish.

a. By Deep-sea Trawling.

It appeared to me, on undertaking my inquiries as to the amount of immature fish destroyed in the ordinary course of the trawling industry, that this object could best be accomplished by the statistical method. Accordingly, during my stay at Grimsby I have endeavoured to keep as exact an account as possible of the amount of small fish landed there, with as much information as I could obtain about the different grounds from which the fish were caught. Owing to press of work in connection with my researches on the definition of sexual maturity, I was obliged at first to limit the scope of my statistics to the plaice, which I soon found to be by far the most important species; and during the first year I could only afford the time necessary to take the numbers of small fish. During the second year I was able to include all plaice, of whatever size, and also to pay attention to the quantity of small haddock and codling landed by trawlers, but it has never been possible to attend to the total numbers of these two species. The destruction effected by shrimp-trawling and various long-shore fisheries did not lend itself to statistical inquiry, and for the present my remarks must be understood to apply only to beam trawling by large vessels, or, as it is generally termed, "deep-sea trawling."

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* Large numbers of haddock about 5 inches long were cast up dead on the shores of the Humber after the gale of November, 1893. No other kinds of fish were noticed by myself on this occasion, the only one on which I have heard of the occurrence of a haddock in the estuary under any circumstances.

With regard to the **plaice** (putting aside the estuary of the Humber, which is the seat of a small shrimping industry, and which annually contributes an insignificant number of small plaice to the market), it soon became evident that all the takes of plaice which included so many small fish that the latter could be packed in separate boxes, were made on the Eastern grounds—that is to say, on any part of the Continental coast from Terschelling on the south, to the Horn Reef on the north, and even further northwards along the Danish coast to Hantsholm (see chart).

My inquiries were facilitated by the fact that vessels which fished these grounds seldom worked any others during the same voyage, so that there was but little admixture in the cargo of the products of different localities. The most usual admixture was in the case of boats which had been fishing off Borkum Island. On the ground nearest the shore of that island the plaice are all small, but on Borkum "rough," only a few miles off, there are plenty of fine fish. Such matters, however, could usually be ascertained in the course of the collection of the records.

It was, of course, impossible to examine all boxes of fish which came to market, and to determine how many were mature or the reverse, so I was compelled to divide my returns into two headings,—(i) those boxes which contained large fish, and (ii) those which contained only small.

The limit of sexual maturity stands, as we have seen, at about 17 inches for the North Sea, but this is not recognised in commercial circles as the natural limit between large and small fish, and I found it convenient to make use of the ordinary market definitions of these two terms. A box of "small" plaice, in market parlance, is one which contains, except in very rare instances, no fish over 15 inches in length, and very few, often none, which exceed a length of 13 inches. A box of "large" may contain all sizes, as long as there are a few large or fair-sized ones on the top. There is an intermediate standard known as "half-fish," consisting chiefly of sexually immature fish; but half-fish are not invariably packed separately, and it is hard to see what boundary of average size may separate a box of "half" from a box of "large." I have only found it possible to deal with two sizes, viz. "large" (including "half") and "small" as above defined.

Of course, in such a classification a great number of immature fish are left out of the category of "small," viz. a certain number nearly always present in boxes of "large," boxes which barely rise to the dignity of "half," and boxes which, though almost filled with small fish, are decorated with a few largish ones on the top.

It may be remarked that the classification is unsatisfactory from the biological point of view, but I prefer to use the trade standard, since the "practical" man is thereby debarred from raising the howl with which he usually greets any attempt at what he chooses to suppose to be a "scientific" method. The actual proportions of sexually mature and immature fish are deducible from averages based on the contents of boxes which are here excluded from the "small."

Even among the "small" the fishermen sometimes find it necessary or advisable to introduce distinctions. Usually all fish from about 8 to 15 inches are packed together, but sometimes there are so many exceedingly small specimens that they are divided into two lots, of which the lesser series of boxes will contain fish not exceeding about 12 inches, and mostly much smaller.

The Eastern grounds, in fact, differ somewhat from each other in the size of fish caught. Thus the "Skilling" (Terschelling) ground off the Texel, nominally a sole ground, yields plaice of which the smallest are usually about eight inches long, so that all are marketable. The Borkum and Skimliko (Schiermonikoog) grounds, where the boats go closer in, produce quantities of smaller fish, down to a size of about four inches; although none of less than six, and few of less than eight, are thought worth bringing home. Very small fish are also caught northwards as far as the Horn Reef, but north of that the fish are about the same as at Skilling. This much the grounds have in common, that, except recourse is had to the few rough patches already referred to, hardly any fish are caught which exceed the market standard of "small," and only the most infinitesimal proportion of really mature fish are taken.

When these grounds were first worked, and for many years afterwards, it seems to be an undoubted fact that they abounded with large fish. Some say that there were no small ones then, but the general and much more probable report is that the little ones were always there as well, but were simply shovelled overboard (just as the very small ones are now), and so never made their appearance in this country. It was only when the large fish failed that the small ones began to be heard of. On the grounds "below" (north of) the Horn Reef it is said that originally there were only large fish, and it seems to be held that the fish there now are larger than the rest. Of this I have not been able to convince myself, either by personal inspection or by observing the fish landed from there, but certainly there are no very minute fish on the trawling grounds in that region.

It is certainly a fact that large plaice are to be caught north of the Reef, but this is in the autumn, and on grounds which lie further out than those frequented by the small. The latter are found in the summer anywhere along the coast, quite close in from the reef to the Holmen, the ground about the mouth of the Limfjord being perhaps one of the most productive grounds. Moderate-sized fish, of which some 24 per cent. may be sexually mature, are to be had at the same season in the offing, but within the moraine previously mentioned. The small fish, I find from my records, were still close in to the Holmen up to the last week of August, 1892, though I could find but few of them there a month earlier, probably on account of bad weather.

On the other hand, about the middle of September a quantity of fine fish always appear in the same locality, but further out, viz. about twelve miles off the light. They stay there for some time, and our boats never neglect to take toll of them, 200 boxes being by no means an unusual "voyage" for a steam trawler. The natural question as to whence they come and whither they go may for once, I think, be answered with some degree of confidence. It has long been known to Baltic naturalists that plaice, larger than the dwarfed native breed, enter the Sound and Baltic in the summer. The Danish fishermen called them "priest's flounders," as being fitter to cope with the sacerdotal appetite than the small natives: naturalists, regarding the Baltic dwarf as the type, considered the immigrants in the light of a variety (*P. platessa* var. *borealis*, Gottsche). They are, in fact, ordinary North Sea plaice, and come, I have little doubt, chiefly from the Great Fisher Bank, whither they appear to return in the autumn, *viâ* the Holmen ground; picking up, most likely, some recruits on the way. There are plenty of large plaice on the Bank in the winter and through the spawning season, but after that, and throughout the summer and early autumn, there are comparatively few there. If the Baltic and Holmen migration theory is correct this is easily accounted for.

The above is rather a digression from the subject of the present chapter—the destruction of immature fish—but it leads us to a point which has a distinct bearing on it. The Horn Reef seems to form a natural boundary between different plaice nurseries, of which the most considerable is of course the vast area of small fish ground south of the reef. I have been inclined to suppose that the grounds north of the reef are the nursery for the Fisher Bank plaice, and that the larger among the little ones find their way thither every autumn; but of this I have no proof.

But, as regards the grounds south of the reef, it is hardly possible to doubt that they furnish every year a contingent to the Dogger and other central grounds. About the end of July our trawlers regularly set out, unless they have better sport in hand, to the White Bank, Clay Deep, Back of the Scruff, Rising Ground,

&c.—grounds which a glance at the chart will show to be exactly on the line from the small-fish grounds to the Dogger,—and there capture a considerable quantity of small plaice. There may be an admixture of larger fish, but the bulk and often the entire catch consists of plaice measuring from 12 to 14 inches. There was no quantity of such small fish on the off-shore grounds before, and they correspond exactly to the largest sizes of the fish on the Eastern grounds, while the time corresponds to that at which the "body" of the small fish disappear from these grounds. The fishermen consider that they are travelling some whither, and not feeding at the locality of capture; and of the nature of their migration I think there can be no manner of doubt. What chiefly concerns us here is the evidence of a large destruction at a certain season of the year of (practically exclusively) immature fish on grounds which lie some fifty or sixty miles from the nearest land.

The following table gives, I believe, a very nearly exact account of the plaice landed from the 1st April, 1893. I cannot speak as to the accuracy of the total amounts previous to that date, as my own statistical inquiries, from January, 1892, to April, 1893, only dealt with the "small" fish. In order to get the other amounts for the earlier period I was obliged to make use of the official returns, whatever they may be worth, arriving at the amounts of "large" by subtracting my own account of the "small," and in June, July, and August, 1892, deducting an amount estimated as the product of the Iceland fishery. For this purpose I deducted only 800 boxes. The number was probably larger, but as I had not kept an exact account of them I preferred to be on the safer side.

My own returns in this table deal only with fish landed by deep-sea trawlers. The Board of Trade figures presumably include also whatever plaice are landed at or sent to the market by shrimpers and other long-shore fishermen, which I have preferred to deal with separately. I also exclude from this table any fish which have been consigned to the market from abroad, or, to my knowledge, from other British ports, since such can have no possible bearing on the Grimsby fishery; but I do not see how the official returns, being based on quantities despatched from the market by rail, can possibly distinguish between fish landed by fishing vessels, and those which arrive at the market by any other means. Consequently the total amounts previous to April, 1893, being taken from official returns, are rather different in scope, as well as in method of collection, from those from April, 1893, onwards; but the amount so excluded from my own returns is not sufficient to make any considerable difference. I should add that there is one large fleet belonging to Grimsby, which

Table showing the Weight, Bulk, and approximate Number of Plaice
fishing power (in voyages of steam-trawlers)

	All Deep-sea Grounds.			North Sea.		
	Total.			Total.		
	Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.
	i	ii	iii	iv	v	vi
1892.						
April	11,000	9,777	1,253,100	11,000	9,777	1,253,100
May	12,000	10,666	1,191,100	12,000	10,666	1,191,100
June	49,000	34,577	3,895,150	10,400	9,244	820,300
July				17,000	15,111	1,820,050
August				10,600	9,422	1,230,800
September . . .	15,000	13,333	1,510,900	15,000	13,333	1,510,900
October	20,000	17,777	1,821,950	20,000	17,777	1,821,950
November . . .	20,400	18,133	1,813,330	20,400	18,133	1,813,330
December . . .	11,000	9,777	977,700	11,000	9,777	977,700
1893.						
January	10,000	8,888	891,950	10,000	8,888	891,950
February . . .	7,600	6,755	680,150	7,600	6,755	680,150
March	10,000	8,888	888,800	10,000	8,888	888,800
	—	—	—	—	—	—
April*	12,256	10,833	1,471,650	12,006	10,633	1,463,650
May	23,727	20,439	2,952,020	17,974	15,756	2,765,700
June	21,792	18,555	2,214,250	12,605	11,205	1,920,250
July	30,590	25,190	2,259,290	16,370	13,814	1,804,250
August	22,890	19,675	1,806,610	14,323	12,821	1,532,450
September . . .	14,078	12,296	1,334,000	13,756	12,046	1,324,000
October	18,214	16,191	1,710,450	18,214	16,191	1,710,450
November . . .	12,621	11,219	1,244,300	12,621	11,219	1,244,300
December . . .	5,140	4,570	470,050	5,140	4,570	470,050
1894.						
January	5,020	4,463	477,650	5,020	4,463	477,650
February . . .	4,132	3,707	377,900	4,132	3,707	377,900
March	9,377	8,341	1,061,150	9,377	8,341	1,061,150
Total for year ending March 1894	179,837	155,479	17,379,320	227,294	125,766	17,171,800
April	20,177	18,705	971,661	18,820	17,619	928,221
May	17,911	15,577	2,174,230	14,015	12,460	2,049,550
June	17,274	15,939	2,139,720	13,827	13,181	2,029,400
July	17,879	15,559	1,752,160	14,118	12,550	1,631,800
August	19,438	17,206	1,886,590	18,606	16,540	1,859,950
September . . .	19,565	17,303	1,871,300	19,565	17,303	1,871,300
Total for six months	114,244	100,289	10,795,671	98,951	89,653	10,370,221

* Totals previous to this date are taken from official returns.

landed at Grimsby by deep-sea trawlers, and (*col.* xvi) *the diversion of from the North Sea grounds in each month.*

North Sea.						Iceland.			
Large.			Small.			Cwt.	Boxes.	Fish.	Voyages.
Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.				
vii	viii	ix	x	xi	xii	xiii	xiv	xv	xvi
8,933	7,941	794,100	2,065	1,836	459,000	...	...	...	...
11,065	9,836	983,600	933	830	207,500	...	...	...	...
6,000	5,774	577,400	3,903	3,470	242,900	...	800	24,000	?
14,683	13,052	1,305,200	2,316	2,059	514,850				
8,435	7,498	749,800	2,164	1,924	481,000				
13,668	12,149	1,214,900	1,332	1,184	296,000	...	...	...	...
19,667	17,482	1,748,200	331	295	73,750	...	...	...	...
20,400	18,133	1,813,330	...	...	...	...	...	...	...
11,000	9,777	977,700	...	...	...	...	...	...	...
9,977	8,867	886,700	23	21	5,250	...	...	...	...
7,566	6,724	672,400	34	31	7,750	...	...	...	...
10,000	8,888	888,800	...	...	...	...	...	...	...
—	—	—	—	—	—	—	—	—	—
9,004	7,964	796,400	3,002	2,669	667,250	250	200	8,000	2
8,549	7,822	782,200	8,925	7,934	1,983,500	5,753	4,683	186,320	20
6,615	5,880	588,000	5,990	5,325	1,332,250	9,187	7,350	294,000	30
13,199	10,995	1,099,500	3,171	2,819	704,750	14,220	11,376	455,040	36
12,546	11,152	1,115,200	1,877	1,669	417,250	8,567	6,854	274,160	21
12,856	11,250	1,125,000	900	796	199,000	312	250	10,000	1
17,529	15,582	1,558,200	685	609	152,250	...	...	...	...
11,703	10,403	1,040,300	918	816	204,000	...	...	...	...
5,043	4,483	448,300	97	87	21,750	...	...	...	...
4,785	4,254	425,400	235	209	52,250	...	...	...	...
4,054	3,604	360,400	78	70	17,500	...	...	...	...
7,671	6,819	681,900	1,705	1,517	379,250	...	...	...	...
199,310	100,208	10,020,800	27,583	24,520	6,131,000	38,489	30,713	1,227,520	110
9,347	9,198	919,800	9,473	8,421	405,150	1,357	1,086	43,440	7
7,990	7,103	710,300	6,025	5,357	1,339,250	3,896	3,117	124,680	25
9,493	8,439	843,900	4,334	4,742	1,185,500	3,447	2,758	110,320	21
11,292	10,038	1,003,800	2,826	2,512	628,000	3,761	3,009	120,360	19
17,062	15,167	1,516,700	1,544	1,373	343,250	832	666	26,640	5
18,408	16,363	1,636,300	1,057	940	235,000	...	...	...	...
73,552	66,308	6,630,800	25,259	23,345	5,836,150	13,293	10,636	425,440	77

makes a practice of landing its fish in London, but at rare intervals sends a cutter to Grimsby. Fish landed in this way are omitted from my own returns, as I think that to include them might lead to erroneous conclusions as to the abundance of supply.

From various causes it was not possible to keep the records for several days in various months, and, in order to remedy the omission, I have made up the amount by means of averages. The method is not an exact one, perhaps, but is probably sufficiently so for our purpose here. In the Journal, where my statistics have already been published in a simpler form, I have made no attempt to supply the omissions, but have simply made a note of the number of days on which no record was made.

The Board of Trade returns deal with weight, while I prefer to use the box as the unit of calculation. Indeed, no other method is possible in statistics taken on the pontoon. The official weights have therefore been converted into boxes in the earlier period, but as weights are more intelligible to many people, I have retained them also, and in the returns since April, 1893, have computed the boxes from my own record in weights.

I must explain that at Grimsby a "box" of fish means a box packed in such a way that a considerable number of fish are above the level of the top; a box which is only filled up to the top is called a "level." Boxes of North Sea plaice, as I am informed by fish buyers, and as I find by experiment, average a weight of nine stone; but boxes of plaice from Iceland, owing to the larger size of the fish, can be packed much higher, and are so packed with a view to tempt the rather unwilling market, and weigh about ten stone each. Accordingly cols. v and xiv require different treatment for conversion into weights.

When a vessel is "single-boating," the fish are landed in baskets and packed in boxes upon the pontoon, but in "fleeting" large plaice are packed in boxes on board of the vessel which catches them, and placed on board the "cutter" for transport to market. In this case, for convenience of stowage, the boxes are only filled up to the top, consequently fish derived from fleets are sold in "levels."* A certain allowance of large plaice has to be made for home consumption, and this, I believe, has been done with sufficient accuracy in counting "levels" as "boxes," though the allowance ought really to be spread over the whole year instead of appearing, as it does by my method, highest in the chief fleeting season. I do not know that there is any home consumption of small plaice.

The approximate numbers of fish are derived by multiplying the boxes by the average number which a box of each class contains. In the case of "small" I have taken 250 as the average. The usual number is rather greater, and sometimes very much greater, if the fish are unusually small, but I prefer to run no risk of exaggeration in this matter. I may say that I have never seen a box of small fish which would have numbered anything like 1036, but we have it, on the authority of Mr. Toozes, that at least one such box has been sold at Billingsgate.* I should say that 400 would be an extreme number for a Grimsby box. The same authority spoke (*ibid.*) of 40 to 45 being the contents of a good box of plaice, and I have often heard it said that a box of "large" fish contains about 50. The fact is, however, that nowadays a full box of so-called "large" plaice, taking one ground with another, averages about 100 fish; the idea of the smaller number being a tradition which dates from the times when really large fish were plentiful in the North Sea.

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* Small plaice are always sold in "boxes," whether derived from fleets or single-boaters.

Iceland plaice are of course much larger, especially when derived from the open grounds. Thus a ten-stone box contains only about 30 fish. The fish landed from Iceland in 1892 were almost all from the open grounds, and I accordingly used 30 as the average per box, but on account of the considerable number of smaller fish brought in from inshore grounds in subsequent years, I considered 40 to be a safer average.

It will be understood, of course, that the numbers of fish in the preceding table are those which are contained in the boxes sold as "large" (including "half") and "small" respectively, and are not intended to represent the numbers of actually large and small fish landed. To arrive at that fact approximately we must have recourse to a further process of conversion. The boxes containing only "small" fish come, as we have seen, exclusively from the grounds on the Eastern side; and of the remainder, even of those in which the largest are only "half" fish, all but a comparatively insignificant proportion are derived from grounds other than the Eastern.

The sizes of fish taken on these grounds differ considerably according to the ground, and on some grounds according to the time of year, but we shall be safe in saying that a box of "large" contains, on an average, 30 per cent. of fish which fail to reach the biological standard of 17 inches, and 10 per cent. of fish which are less than 13 inches. I do not think it would be an exaggeration to say that there are 30 per cent. of actually immature fish, whether male or female, but it is difficult to make a perfectly reliable average, and that which I have formulated above, being well within the mark, must suffice for our present purpose. A box of "small" contains at least 90 per cent. of less than 13 inches, and 100 per cent. of sexually immature.

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* N.S.F.P.A., Rep. Conference, 1892, p. 11.

I do not know what may be the standard of maturity in Iceland fish, so have restricted my calculations to those derived from the North Sea. The results are given in the following table.

Table showing the numbers and proportion of plaice of different sizes landed at Grimsby by deep-sea trawlers in one year.

	Sexually							
	Mature. 17 inches and above.		Immature. Below 17 inches.		13 inches and above.		Below 13 inches.	
	No.	%	No.	%	No.	%	No.	%
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.
1893. April . .	557,480	38	906,170	62	783,485	53	680,165	47
May . .	547,540	19	2,218,160	81	902,330	32	1,863,370	68
June . .	411,600	21	1,508,650	79	662,425	36	1,257,825	64
July . .	769,650	42	1,034,600	58	1,060,025	42	744,225	58
August. .	780,640	50	751,810	50	1,045,405	68	487,045	32
September .	787,500	50	536,500	50	1,032,400	78	291,600	22
October .	1,090,740	63	619,710	37	1,417,605	83	292,845	17
November .	728,210	58	516,090	42	956,670	76	287,630	24
December .	313,810	66	156,240	34	405,645	86	64,405	14
1894. January .	297,780	62	179,870	38	388,085	81	89,565	19
February .	252,280	66	125,620	34	326,110	68	51,790	14
March . .	477,330	44	583,820	56	651,635	61	409,515	39
Total for year .	7,014,560	43	9,137,040	57	9,641,820	72	6,519,980	28

I think it may be claimed that this table throws more light on the actual destruction of under-sized fish than any evidence that has yet been brought forward on the subject. Of course the numbers of fish given are not exact, but I emphatically assert that the method of computation, so far from exaggerating the proportion of small fish, tends rather to under-estimate it, yet we find that in a whole year's trawling, on all North Sea grounds, 57 per cent., or more than half, of the fish had never had a chance of reproducing their species, and so contributing to the up-keep of the supply.

I do not know that there is any actual necessity to say anything more as to the destruction of immature plaice, since if the above table does not prove to the satisfaction of any reasoning being that it is serious, nothing will do so. I will draw attention, however, to the difference in proportions which manifests itself in different months of the year,—especially, for a reason which will hereafter appear, in the case of the series of columns dealing with fish of 13 inches and above, and those which fail to reach even that modest standard of size. It will be noticed that if we eliminate the months of March to August inclusive, the proportion of very small fish is not a large one.

I have never made any attempt to collect the numbers of fish under 8 inches, the limit proposed by the Parliamentary Committee, because there is no necessity to do so. No one conversant with the Grimsby market will be disposed to say that the subjoined table of proportions is far from the mark:

Proportion of plaice landed at Grimsby: 8 inches and above, 99·9 per cent.; less than 8 inches, 0·1 per cent.

Unfortunately the small fish *landed* at Grimsby by no means comprise all those which are destroyed by Grimsby trawlers. Certainly on any but the Eastern grounds very few unmarketable fish are caught; and on the Terschelling ground and those north of the Horn Reef there are no very small fish, but between the reef and Terschelling the trawl often brings up a quantity that are not saleable. I cannot attempt to estimate the quantity annually captured in this manner, but can give an instance which perhaps will serve sufficiently well. In 13 hauls made in the neighbourhood of Borkum and Schiermonnikoog 141 baskets of plaice were caught. Of these 93½ contained saleable fish from about seven to thirteen inches, which were brought to market. The remaining 47½ baskets, consisting of fish of about four to seven inches, were shovelled overboard. In actual numbers probably more fish were thrown away than were brought home.

The question has often been asked, **is a fish killed by being caught in the trawl?** The answer given on all hands is that it depends upon circumstances. It depends also on the kind of fish, since flat-fish as a class are rather hardier than round-fish, and some flat-fish are hardier than others. The plaice, with which we are now dealing, is about as hardy as any, and if the ground is clear, and there is not much weight of fish in the net, a plaice will survive a short haul, and even a moderately long one; but the smaller the fish, the more liable it is to injury.

When there is a big bag of fish, many of them will be mortally injured, even in only a moderately long haul on clear ground, the small ones especially being liable to be crushed or jammed between the meshes of the net; but if the ground is dirty, with quantities of weed, or, still more, if it is soft, with either loose sand or mud, the fish has not much chance of survival.

The length of haul depends a good deal on the nature of the ground. Thus on open grounds I find the average duration of a steam-trawler's haul is about six hours, but some skippers make even a shorter average haul. On intricate ground the haul must be shorter, and averages about three hours. The hauls made by smacks when single-boating are rather longer, averaging about seven hours on open and five hours on intricate grounds. Fleeting smacks make, I believe, rather longer hauls as a rule. On the Eastern grounds, especially when there is a "body" of small fish, the hauls are generally rather short.

But granted that the small fish comes aboard alive and well, it by no means follows that it regains its native element in the same condition. The chances are that, on a steam-vessel, the bag of fish is left swinging about from the derrick for a quarter of an hour or so while the crew are occupied in shooting the second trawl, so that the whole weight of the catch is on the undermost fish. Then the cod-end is untied, and down comes the whole collection with a crash on to the deck, which cannot be particularly healthy for the small ones. On a smack which only carries one trawl, if the position is favourable for shooting again without a long beat up to windward, all hands set to work to get the trawl cleared, and mended, if necessary, before the fish receive any attention. When there is time to attend to the fish it is done in the manner calculated to take least time. The turbot must be picked out and bled as soon as possible, and all the marketable fish are cleaned, or at least sorted in separate pounds on the deck, before the small stuff and rubbish is shovelled overboard. On a fleeting smack it may be necessary to pack all the big fish for transference to the cutter before anything else can be done; and in any case, though some small plaice are occasionally alive when pitched overboard, and though I have known a more than usually provident skipper pick out and return a few small plaice, and even moderately large turbot, it may be taken that if a fish is caught by a deep-sea trawler, it is done for, whether it comes to market or not.

A few words as to the **share of different vessels in the destruction** may not be amiss. It can be best illustrated, I think, by the records of a single month. I have not kept my returns in sufficient detail to give particulars for the whole period.

In May, 1893, there were landed at Grimsby 7644 boxes of "small" plaice from the Eastern grounds. Of these, 5587 boxes were contributed by steam-trawlers in twenty-nine voyages, viz. twenty-two voyages by British and seven by foreign steam-trawlers. The remaining 1738 boxes were landed by smacks. Some of the smacks were "single-boating," but most of the stuff was derived from three fleets working the Terschelling sole ground and eastwards to Borkum. I have not the exact numbers by me, but certainly not less than forty sail were engaged, and yet landed only about one fourth of the amount which was brought in by the steam-trawlers. The twenty-nine "voyages" of the latter might have been effected in the time by only eight or ten vessels. It must be added that the prevailing calms or light winds tended to bring the difference of efficiency as between steam and sail power into greater contrast, as the smacks, in addition to difficulty in fishing, were considerably delayed in landing, the particular fleets engaged being dependent on themselves for "cutters," instead of having steam-cutters.

I have little knowledge of the proceedings of vessels which do not land their catches at Grimsby, but I gather that, in proportion to the strength of the fleet, as much small plaice is destroyed by Hull as by Grimsby boats. Indeed, I was given to understand that in 1892 two large Hull fleets paid a visit to the small-fish grounds, though they did not stop there long. Grimsby during that year had only one small fleet on the Eastern side.

At the Conference of 1890, a number of Hull and Grimsby smack-owners voluntarily bound themselves not to send their fleets to fish a defined area, the western limit of which is shown on the chart by a chain line. This engagement, which does not appear to have applied to steam-trawlers or "single-boating" smacks, has, so far as I know, been carried out. It will be observed that the area does not include a large stretch of ground frequented by small fish.

Of Lowestoft proceedings I know even less, but I am bound to say that I have read the evidence given before the Parliamentary Committee from that port with some surprise, if with no less respectful sentiment. The grounds worked by Lowestoft vessels were roughly defined by a witness as lying between the parallels of 51·30° and 53·30°, and it was stated that boats rarely went to the grounds about Heligoland.

Unless I have been misinformed, there were at the time three fleets of Yarmouth and Lowestoft boats engaged along the coast from Terschelling to Borkum, *i. e.* about the northern limit of the aforesaid rough definition and a little beyond it. There were also one or two Lowestoft boats in a fleet landing at Grimsby.

Evidence was given that soles or plaice of less than 8 inches were hardly ever seen at Lowestoft. I can only say that our vessels seemed to be catching plenty of smaller plaice on the same ground as the Lowestoft men, but perhaps the latter were fortunate enough to avoid them.

Very small plaice or soles are rarely seen in the Grimsby market in winter, and if by chance a few boxes attracted my attention I was almost always informed that they had been culled out of a consignment from Lowestoft.

I found it impossible to keep statistical account of the mature and immature **soles** landed, nor have I made any attempt to secure even the total numbers. I may remark that large numbers are consigned from abroad, and some from our own western ports, but I am not aware whether these have been deducted in the preparation of official returns. If they have not, the returns are worse than useless.

With regard to the destruction of immature soles by deep-sea trawlers, I have myself seen one immature specimen caught in the course of my peregrinations on board of Grimsby vessels. I have examined a good many catches brought to market, but have never been able to find any large proportion of undersized ; probably the whole amount of sexually immature fish does not exceed 30 per cent., nor is there evidence that many soles too small for market are destroyed at sea by Grimsby vessels. I do not know that any of less than 8 inches are brought in. I often hear of quantities of very small soles being caught, but whenever samples have been submitted to my inspection they have consisted exclusive of solenettes (*Solea lutea*), useless creatures which never grow more than about 5 inches long. Such seem to be common on the Well Bank, and also on the sole and small plaice grounds on the eastern side. The very small stages of the common sole appear to me to live too close inshore for our deep-sea trawlers to get at them.

I have not been able to collect continuous statistics of the proportion of immature **turbot** landed. Turbot and brill are always laid out in rows for sale, and to collect the total numbers and proportions of large and small would involve counting every fish on the pontoon—a task for which my other occupations left no leisure. However, by counting them for a considerable number of days one probably arrived at a fairly trustworthy estimate, and by this method I found that the proportion of fish under 17 inches does not exceed 30 per cent. except during the time when the Eastern grounds are being worked. The limit of sexual maturity in the female stands at about 18 inches, but I have not made any calculations upon that basis. Of the fish from other than Eastern grounds which failed to reach 17 inches, I always found that a large proportion were mature males, since the male may be fully mature at only 12 inches. Very few fish of less than 12 inches are brought in from any ground, and I do not think many are caught by deep-sea trawlers. I do not know that any of less than 10 inches are caught.

But, as regards sexually immature fish, the number caught on the Eastern grounds is very considerable. Thus in June, 1892, the aggregate of thirty-one " voyages " of steamers and smacks on the

Dutch, German, and Danish coast comprised 4623 turbot, of which 786 or 18 per cent. measured 17 inches or more, and 3837 or 82 per cent. were less than 17 inches. The highest proportion of immature reached in individual voyages was 100 per cent. and the lowest 28 per cent., but in only two instances did it fall short of 50 per cent.

In the following month of the same year eighteen voyages comprised 2435 fish, of which 69 per cent. were less than 17 inches. This slight diminution in the proportion of the immature seemed to be related to a slight movement offshore of the bulk of the small plaice on which the Eastern trawl fishery is mainly dependent. The smallest turbot apparently lived closest inshore.

With regard to **brill** I have not much evidence of any very extensive destruction of immature members; it appears rather variable. As a rule, not very many are brought in from the Eastern grounds, but sometimes the proportion is quite considerable. I cannot attempt to formulate a percentage, but can at least say that it is much less than in the case of turbot. A lot of immature brill are sometimes landed from our own coast near Mablethorpe. Very few brill of less than 10 inches are landed by deep-sea men from any ground, and I think very few are caught. I have hardly ever seen an 8-inch brill in the market.

The proportion of immature **lemon soles** landed from any ground is not very considerable. A good many are sometimes brought in from grounds near our own coast, and a number of very small ones are said to be caught sometimes about the Inner Dowsing, but on the whole I do not think the destruction that takes place is of great moment.

Though a flat fish of the hardier kinds has, under the most favourable circumstances, some small chance of surviving its capture in a deep-sea trawl, it may be taken that a **round fish** has none. This is partly due to structural differences of the gill-cover, which, adapted to the burrowing habit in flat fishes, proves also efficacious in keeping the gills closed, and therefore moist, when out of water; but the chief difficulty with which a round fish has to contend is its air-bladder. All the trawl round-fish usually met with in the North Sea are provided with a closed air-bladder, by the contraction or expansion of which the fish is enabled to maintain itself at any depth which it desires; but it is only able to adapt this apparatus to gradual changes of depth. Consequently, when it is suddenly drawn up from comparatively deep water, the diminution of external pressure is not sufficiently gradual to allow of the muscular apparatus keeping due control of the gases within the bladder. The latter expands, and the fish, though it arrive at the top otherwise uninjured, cannot get down again. Thus when the trawl warp is straight up and down in hauling, a number of round-fish usually float up to the surface through the mouth of the net or the large meshes of the square, and, engaging the attention of the gulls, perish without ever coming on deck. Moreover I believe that pressure or injury in the trawl may induce what I suppose is a paralysis of the muscles of the bladder, so that the same effect is not invariably due to mere alteration of bathymetrical position, but the result, which would be the same in either case, is more important to us at present. The fish, if its injuries be confined to the expansion of the bladder, is certainly not beyond remedy, but the remedy must be rapidly administered. Liners, who commonly work in deep water, succeed in bringing many of their fish home alive in the well, and these may live in floating boxes for months afterwards. The method adopted is to release the expanded gases by pricking the fish with a needle, and letting the air escape, great care being taken not to puncture the liver in the process. I will leave my readers to conjecture what chance there is of trawl fishermen adopting this practice with regard to unsaleable round-fish. In any case the fish would have to be returned to the water very shortly, and probably most of them would be dead ere the surgical assistance arrived.

I have made no attempt to estimate the proportion of sexually mature and immature **cod** landed by trawlers. It would be extremely difficult to do so, since the larger immature fish are much mixed up with mature ones. I paid very little attention to the species at all until the winter of 1892, when my attention was attracted to the considerable and, as I was told, unprecedented quantities of codling which were being landed by trawlers from certain grounds.

Local custom divides the individuals of this species into four sizes. Up to about 20 inches they are "codling," thereafter they rank as "sprags," until at about 30 inches the dignity of "half-cod" is attained. Larger fish are simply "cod." A sprag is therefore on the borderland of sexual maturity, a condition of which all codling fall short.

The catches of codling to which I have referred first became noticeable in November, 1892, and were all derived at first from about a ground known as the Yorkshire Hole or Sole Pit. The fish seem to have continued there until February, and were chiefly pursued by several steam-trawlers. The largest "voyage" landed comprised 122 boxes for about a week's fishing. Towards the end of February a good number began to appear from off Flamborough Head, 40 boxes being obtained thence by one vessel, but they did not remain there very long.

As a rule, codling do not form a very important item in a trawler's voyage. They are to be had everywhere, but nowhere in very large numbers,—a few boxes, perhaps only half a box, being a common feature in a voyage. Considering it probable that there might be a regular migration of these fish to the grounds mentioned, I commenced to take account of all trawled codling brought to market, but there has been no recurrence of anything like a similar congregation of the fish, though the total number caught has not diminished, as the following figures show :

		Boxes.			Boxes.
1892.	November (last week only)	180	1893.	November, less 1 day	2491
	December	825		December, less 8 days	2730
1893.	January	1605	1894.	January	3096
	February	1763		February	2607
	March, less 6 days	2037		March, less 6 days	2363
	April	1596		April, less 4 days	1093
	May, less 1 day	1204		May (record imperfect).	
	June, less 1 day	1490		June, less 1 day	986
	July, less 1 day	1838		July	1708
	August, less 5 days	2717		August, less 2 days	2140
	September, less 7 days	2123		September	2636
	October	2939			

The chief deduction that can be made from the above figures is that, in the absence of any recurrence of large catches from particular grounds, the congregation noted in the winter of 1892 cannot be regarded as a regular feature in the life history of the species. It was not associated with any unusually severe weather.

About 100 fish, of about 12 to 20 inches, go to a box in the above figures, but as I have no information as to the total number of cod landed by trawlers, we cannot formulate proportions of mature and immature fish. We can say, however, that there is a considerable destruction of immature fish, not specially confined, save in exceptional seasons, to any particular grounds, and certainly not to those on the Eastern side.

The small fish destroyed are not of course confined to those which are landed, as unsaleable fish are simply pitched overboard. On clean grounds most of the very small codling pass through the meshes of the net, but on a part of the Great Fisher Bank where the ground is covered with dense growth of "lemon-weed" (*Flustra foliacea*), I have seen quantities of cod from 2 to 4 inches long brought up and destroyed.

The **haddock** becomes mature at about 14 inches, but is marketable from about 10 inches upwards. Very few of less than 10 inches are brought ashore, but considerable numbers, down to about eight inches or a little less, are caught, and of course are destroyed.

Smaller fish are sometimes, like the small cod, entangled in the net amongst weed or other rubbish.

Small haddock are trawled on pretty well all the grounds of the North Sea, except on very shallow inshore areas. They are packed separately from the larger ones, though boxes of large fish contain a proportion which are actually immature. I have collected the number of boxes of small fish landed since October, 1892, and append the figures for whatever they may be worth, in the absence of statistics showing the total amount of all sizes collected in the same way.

		Boxes.			Boxes.
1892.	October	542	1893.	October	8457
	November	1335		November, less 1 day	6712
	December	1440		December, less 8 days	5792
1893.	January	1416	1894.	January	5248
	February	1471		February	3848
	March, less 6 days	1107		March, less 6 days	5363
	April	2424		April, less 4 days	8502
	May, less 1 day	2890		May (record imperfect).	
	June	3596		June, less 1 day	5570
	July, less 1 day	3841		July	6039
	August, less 5 days	5761		August, less 2 days	6798
	September, less 7 days	4670		September	6587

β. *By other Methods of Fishing.*

Apart from deep-sea trawling there is no doubt that a certain amount of destruction is effected by various other methods of fishing. Drift-netting may be left out of the question, since, though on the south coast I have seen considerable quantities of under-sized hake brought in by the drift-netters, I do not know that this fishing is injurious in the North Sea to any kinds of fish except those which form its object, and with which we are here in no way concerned.

Line-fishing.—In deep-sea long-lining and hand-lining, and in inshore lining generally, there occurs without doubt a considerable destruction of sexually immature cod, and, in the deep-sea branch of the industry, a very material destruction of immature halibut, but mainly in grounds which lie beyond the boundaries of the North Sea. It is hardly within our province to discuss the latter, and with regard to the cod I am not in a position to give information in sufficient detail to be of much value. It may be remarked that the destruction of small fish caught on the lines is to this extent wanton, that most hooked fish would survive if returned to the water.

With the exception of the halibut, which is of no great account as a North Sea trawl fish, I do not know that any flat-fish are commonly captured by deep-sea liners. It is natural to suppose that turbot and brill may be occasionally caught, as on other coasts, but I do not know for a fact that they are.

Though the smaller kinds of flat-fish are not generally fished for by inshore liners on that part of the east coast of England with which I am best acquainted, there is at Scarborough a regular line-fishery for soles during a part of the year, but practically no immature soles frequent the ground. In Lough Swilly, on the north coast of Ireland, there is, as I am informed, a considerable destruction of small soles by line-fishers, but I know of nothing of the sort in the North Sea.

Inshore trawling.—Of the proceedings of inshore trawlers in the Wash, and on the coast to the south, I have no special knowledge. North of the Wash to the Humber I do not think there is much trawling within the three-mile limit. From Donna Nook to the Tees estuary the legitimate use of the fish-trawl in inshore waters is restricted to a portion of Bridlington Bay, but I am not acquainted with the results as regards immature fish. There was formerly a good deal of fish-trawling in the Humber, but this is now forbidden by the bye-laws of the local Fisheries Committee, though the practice has not, I believe, been eradicated. With the exception of a small proportion of large soles between July and October, there are no mature trawl-fish, except dabs and flounders, in the river. Whatever destruction now takes place may be best considered in connection with shrimp-trawling.

Shrimp-trawling.—Shrimp-trawling is carried on in the Humber, under the provisions of the Fisheries Committee's bye-law, from the 1st March to the 31st October. About fifteen cutter-rigged boats are engaged. The largest is of 22 tons; about eight are from 8 to 11 tons, and the remainder from 15 to 18 tons. All carry similar gear, viz. a trawl of shrimp mesh, with a beam not exceeding (by enactment) 20 feet in length, and a thick hempen ground-rope. Some of the larger vessels also possess what are called sole-nets, viz. trawls of a larger mesh than that which is used for shrimps, and, in spite of the provisions of the bye-law, did, within quite recent times, use them in the river; but I believe that the Committee's officer, though hampered by the want of anything in the shape of a police-boat, has done a good deal to check this practice. Be this as it may, all fish brought to market by these boats purport to have been caught in the pursuit of their legitimate industry, so may be considered under the present heading.

The fish landed consist of soles, plaice, flounders, and a few common dabs. The quantity of fish landed is never large, and would hardly deserve consideration were the general supply more abundant.

Soles, however caught, are not very numerous, sixty pairs being considered a very fine night's work for one boat, while the quantity is usually very much less. Unfortunately they are nearly all immature. Indeed, up to the end of June hardly a mature fish is to be found in the river. About the beginning of July a certain number of larger, spent fish begin to drop in, presumably from the offshore spawning grounds. They do not remain long, and very few Humber soles of any size appear in the market after September. The smallest fish landed measure about six inches; at the period of the greatest abundance of mature fish I do not think that the latter ever exceed 16 per cent. of the total, while prior to July about 88 per cent. are immature.

The plaice brought ashore are sold mixed up in boxes with flounders and dabs. Six hundred of such boxes would probably more than represent the total products of the whole fishery for a season. The plaice measure from 6 inches up to about 11 inches, but some reach a length of 14 inches. I found a box brought on the pontoon, and fairly typical to all appearance, to contain 425 plaice from 6 to 11 inches (averaging 7·71 inches), and 34 flounders from 5 to 13 inches.

I have devoted considerable attention to the question of the destruction of small fish by shrimp-trawling in the Humber, and may briefly summarise my results.

It must first be remarked that "shrimp-trawling" is an expression used to comprise the fishery for two distinct creatures, viz. the common brown shrimp (*Crangon vulgaris*), and the pink shrimp or prawn (*Pandalus annulicornis*), which must not be confused with the true prawn (*Palæmon serratus*) of the South coast, nor with the Norway lobster (*Nephrops norvegicus*), though all the last three species are often spoken of as prawns.

Speaking generally, shrimps and prawns do not consort much together; the shrimps prefer the shallow grounds, in most cases near the margin; while the prawns affect deeper water, on grounds covered with "ross," the accumulations of a tube-forming worm (*Sabellaria*) on which the prawns appear to feed.

Very few flat-fish are found on the prawn-grounds, and consequently when prawning the boats catch very few of them. The eight or nine smallest boats restrict themselves almost entirely to prawning, and so do little harm to the flat-fish. On the shrimp-grounds, however, there are many small plaice, the capture of which is unavoidable. Large numbers of dabs are also caught, and a fair number of soles may likewise be present on the shrimp-grounds.

The bulk of the Humber soles, however, seem to affect rather deep parts of the channel, with a bottom of mud or clay, where no fisherman would go if he really purposed to get a good bag of either shrimps or prawns.

Great numbers of whiting, mostly very small, and considerable numbers of very small cod, are found in all parts of the river worked in either shrimp- or prawn-trawling, but none of these are ever brought ashore, and only flat-fish of the sizes which I have mentioned reach the market, though many much smaller ones are caught. A certain number of lemon soles are taken, but nearly all of them so very small as not to be worth keeping.

Having thus briefly glanced at the *capture* of small fish by shrimp-trawling, it remains to consider what proportion, apart from the comparatively small number landed, are thereby *destroyed.**

I have made it clear, I think, that on the prawning-grounds the quantity of flat-fish taken is not of moment, so that prawn-trawling may be dismissed as practically innocuous to those kinds of fish.

The shrimp-ground known as "Paull Middle," which lies considerably higher up the river than the rest, does not furnish a very significant amount of flat-fish, and on the lower grounds, though a considerable number, including very small and delicate forms, are taken, the number is nothing like that of which we have evidence from the Mersey shrimping-grounds on the North-west Coast.

In the ordinary course of the Humber industry, when the trawl comes on board its contents are shot into a box, or on to the deck, and as many as possible of the unsaleable products are picked out by hand and pitched overboard. In this way quantities of hard-heads (*Cottus*), bull-routs (*Agonus*), and gobblers (*Liparis*) find their way back to the water, as also any number of shore-crabs and swimmer-crabs. I think it would be wiser to destroy the hard-heads, the gobblers, and the swimmer-crabs, as all these seem very destructive, and are of no known use. I do not find, from the contents of their stomachs, that the bull-routs do much harm; and the shore-crabs, though destructive, deserve some consideration on account of their function as scavengers.

By the same process the young whiting and cod, being of no value, are returned to the sea,—to be out of the way, if with no more provident intent. The saleable flat-fish are put on one side; the remainder, if large enough to attract attention, being thrown overboard. Unsaleable soles are most carefully returned, their future value being most fully recognised by the shrimpers.

The catch of prawns or shrimps having thus being roughly cleared, is placed in the sieve and riddled over the side of the boat. The bottom of the sieve consists of parallel wires, with occasional cross-bars to ensure rigidity. In their own interests many of the fishermen have the wires three pennies' thickness (about $\frac{3}{16}$ inch) apart, and wish that this gauge might be made compulsory, as the use of finer sieves tends to lower the market price of the prawns. Until I had made the experiment I did not suppose that small flat-fish would be likely to pass through such a sieve, but as a fact they do, and thus practically all that are too small to have been picked out in the first sorting by hand find their way back into the river, in company with the smaller prawns or shrimps.

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* For a detailed discussion of the Humber shrimp-trawling question *vide* Journal Mar. Biol. Assoc., vol. iii, p. 90.

Fortunately it is absolutely essential to the profitable conduct of the fishery that all these operations should take place in so short a time that the shrimps can be got into the pot alive, and that the latter should be as free from rubbish as possible. I have known Thames shrimpers to boil the whole hotch-potch of shrimps and small fish together, and sort them afterwards, but the Humber men always sort them first.

Thus we see that the interests of the shrimp-trawler compel him to return all unsaleable fish to the water as soon as possible. But, as it may occur to the reader, we have seen that the mere fact of being caught in the trawl is frequently fatal to fish in deep-sea operations, and it may be asked—is not this equally the case in shrimp-trawling? My answer, after careful experiment, is in the negative, and for the following reasons.

The shrimp and prawn-grounds are none of them of great extent, they are intricate, and can only be worked with the tide, so that short hauls are an absolute necessity. I do not suppose a haul often much exceeds two hours, and I consider one hour to be about the usual period.* The ground is mostly clean, or the boat is brought up if the net gets among clay banks or much rubbish, and the men are obliged to haul. The shrimp-mesh is very fine, and very stiff, the cotton being heavily tarred, and it is rather a rare thing to find small fish jammed amongst the meshes. A larger mesh, more liable to open and shut, would probably be more injurious. As a fact I find that the fish come on deck alive and vigorous, unless they happen to have been spitted by the prow of a prawn or nipped by a crab.

No doubt the most delicate forms are the whiting and cod, especially the former, and if either are allowed to lie on deck they soon succumb. If pitched overboard at once they swim off apparently none the worse, since the depth of water is not sufficient to cause loss of control over the air-bladder on being brought to the surface. I have made experiments to test the vitality of these fish, and find that even in the unfavourable conditions of a tub of stagnant water a large percentage will survive for an hour, and that fish which appear sickly at first, for the most part recover after a time.

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* If the hauls ever exceed an hour it is in contravention of the Committee's bye-law on the subject.

Of the flat-fish the little plaice were especially hardy, and would survive not only a good deal of exposure on the deck before being placed in water, but also the two miles' jolting in a cart involved in conveying them from the docks to the Cleethorpes Aquarium,—a process which proved too much for most of the cod and whiting.

Soles* and lemon soles are seldom injured by capture in a shrimp-trawl. The latter are especially hardy, and a number of very small ones survived all the vicissitudes of capture and travel, and lived for about a year in the Cleethorpes tanks, where they would probably be still flourishing if they would only have let each other's tails alone. Soles which had been chafed, either in the net or in handling, ultimately died in the tank, as they always appear to do in confinement; but I do not think it follows that they die if returned to the sea, as specimens are trawled which have evidently recovered from serious wounds.

Dabs, especially very small ones, are delicate, and will survive but little exposure on deck, or injury from chafing. This matters the less, as the species, being a keen competitor in the matter of food with more valuable kinds, is not deserving of any special protection.

Flounders are about as hardy as any fish I know.

I consider, therefore, that we may acquit the Humber shrimp-trawlers of any very great destruction of small fish other than those which they bring ashore to sell. I do not pretend that the same judgment can be passed on the industry as conducted on the north-west coast.

Longshore shrimping by shove-nets.—If, however, we acquit the trawlers, we can hardly do the same for the shore-shrimpers. The shove-net used along the Humber sands (and southwards along the whole coast of Lincolnshire, I believe), is a sufficiently formidable engine. The frame is shaped like the letter T, the cross-piece representing the beam, which is nine feet long, with a short iron upright at each end; while the shaft, represented by the body of the letter, is rather shorter, and has a short transverse handle. The lower end of the net is laced to the beam and uprights, the upper end being gathered on to an iron ring, which is drawn up the shaft by means of cords passing through the handle of the latter. In this way the belly of the net is made exceedingly rigid, and its meshes are almost closed, so that shrimps, &c., slide right up into a small bag situated just below the ring.

These nets are shoved along the margin at low tide, either by night or day. Great numbers of small fish are caught, and many undoubtedly destroyed, since the men are not always so careful as they might be to sort them at the margin. Small soles, turbot, and brill are certainly returned at once if observed, but "flat-fish," *i. e.* small plaice, are not held of much account.

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* Except on muddy grounds, where shrimpers have no legitimate business.

The following is, I think, a fair sample of the catch of one net for a single tide. The worth of the shrimps was estimated by the captor at 2s. 6d.

Shrimps	4 quarts.	
Sole	4 = 2⅜ to 3¼	inches.
Turbot	1 = 3⅛	,,
Brill	2 = 3⅝ to 4¾	,,
Plaice	896 = 1½ to 4½	,,
,,	12 = 4¾ to 9	,,
Flounders	6 = 2½ to 4⅞	,,
,,	3 = 9	,,
Dabs	3 = 1¼ to 1¾	,,
Smelts	5 = 3½ to 3⅞	,,
,,	1 = 6½	,,
Dragonets	23 = 1¾ to 2¾	,,
Gobies	261	
Sticklebacks	29	

A few sand-eels, bullrouts, and pipe-fish.

A lot of crabs are always caught, but got rid of as soon as possible. The shrimper, resting the end of the shaft against his chest, can wade along with his hands free, and so intercept a good many unsaleable items on their way up to the bag. He can also swing the basket he carries in front of him, and occupy himself in lightening it by culling out a good many of the small fish. So many as benefit by this process are in no way injured by being caught, but I think a large proportion always remain to be sorted when the tide is over, and on dark nights very little sorting can be done while the fishing is going on. If at the end of the tide the young fish were culled out at the margin, or somewhere along the course of the numerous pools and runnels of brackish water which cross the sands, I imagine no harm would be done, as most of even the smallest flat-fish will survive a considerable sojourn in the basket; but the favourite sorting-ground is at high-water mark, or the whole catch is simply carried home and sorted there; and I think in very many cases not the slightest effort at culling out anything except crabs is made until the fisherman gets home. Consequently I fear the destruction of small plaice in shove-netting is very large. Even the meagre number of soles, turbot, and brill are important when we consider the present scarcity of these species.

Shrimp-seine or Horse-net.—In addition to the shove-net, there is in use along the south shore of the Humber, and along the Lincolnshire coast generally, a still more abominable engine, variously known as a shrimp-seine or horse-net. This is nothing more or less than a trawl of shrimp-mesh, with a mouth 18 feet wide, kept open by a pole. Two short wooden beams, heavily loaded at the lower end, serve to keep the wings upright, and to separate the head and ground ropes. The whole affair is attached by bridles to the axletree of a small one-horse trolley driven by the fisherman.

The net is worked over the same ground as the shove-net, and only differs from the latter in its greater catching power and destructiveness to small fish. "Jehu" has to attend to his horse, and can spare no attention for sorting purposes. Consequently, when the net is cleared, the whole contents are shot into a fish-box and there remain until the fishing is over. It need hardly be said that capture in this case means destruction.

"**Flat-fish nets.**"—A "flat-fish net" is a piece of net, of a mesh about equal to that used for herrings, twenty yards long by a yard wide, corked at the top, and leaded at the bottom. The ends are kept upright by short beams, and the whole is dragged along the margin by a couple of men, keeping at a regular distance apart from each other. Such a net is occasionally used at Cleethorpes. It is designed for the capture of plaice, flounders, and any soles that may be near the margin, and is hauled by the men walking ashore.

As it is preferably used on a rising tide, only the marketable flat-fish are destroyed, as any smaller ones are left to squatter down into the wet sand, and are soon covered by the tide. Of course all the plaice taken, and most of the soles, are immature.

Seining.—Seining is practised in the Humber for smelts and eels, but a good many flat-fish are of course caught, and those above about 6 inches are taken. As in the case of the last net mentioned, the smaller ones suffer no injury, the tide soon coming to their relief. The mesh is smaller than that of the "flat-fish net," being about ½ inch between each knot.

Stake-nets, of the same mesh as the seines, are erected at Cleethorpes and Humberstone in the winter for the capture of sprats. The fishery is a very uncertain one, so that the length of time the nets remain up is variable. It appears to be found most convenient to empty the whole catch into baskets or barrels, and cart them home before sorting. In this way a few small flat-fish and a great number of small whiting and cod are destroyed, as well as, in the early part of the season at least, a quantity of unsaleable sprats and young herring, locally termed "scad." The owner of the nets being to some small extent interested in agricultural pursuits, the refuse fish is found useful for manure.

Note added in the press.—In comparing my statistics with those furnished by the Board of Trade a considerable discrepancy is found to exist. The official total (of plaice) for the year ending March 31st, 1894, is 168,000 cwt., *i. e.* 11,837 cwt. less than the amount indicated by my inquiries. Seeing that the latter purport to deal only with plaice landed by deep-sea fishing vessels, and exclude even occasional contributions from a fleet which ordinarily lands at Billingsgate, while the official figures presumably embrace all fish from whatsoever source derived, it is somewhat remarkable that my returns should give the larger total.

I acknowledge the objection that my return is completed by the deduction of averages for a certain number of days on which no actual observations were made, but when we come to compare separate months, in which no such source of possible error exists, we do not arrive any nearer to an agreement, or even to a consistency of disagreement. Thus in April, June, October, 1893, and June, 1894, my figures are 2256, 3792, 214, and 2274 cwt. in excess of those given by the Board of Trade for the same months; whereas in January and February, 1894, the official figures exceed my own by 1980 and 2868 cwt. I will content myself with the incontrovertible statement that *both* series of statistics cannot be accurate.

CHAP. V.—PROPOSED REMEDIAL MEASURES.

Having admitted a grave deterioration in the returns of the North Sea trawling industry, I think the contents of the last chapter furnish us with quite sufficient evidence to allocate the causes in so far as Grimsby vessels and the general fishery of the district are concerned.

To my mind they fall under two distinct headings:

(i) An immense destruction by deep-sea trawling of immature plaice and turbot on shallow grounds on the Continental coast, frequented only by immature members of the first species, and chiefly by immature members of the last; visited also by spawning soles, turbot, and brill.

(ii) A serious destruction on our own coast by various methods of longshore shrimping of immature plaice, and of immature soles, turbot, and brill, in proportion to the abundance of these species. A serious destruction (but not necessarily involving destruction of the very young stages) of immature members of these species, especially of soles and plaice, by shrimp-trawling and inshore fish-trawling on our own coast.

Though I can produce no information on the subject, it is reasonable to suppose that the large shrimping industry in the inshore waters of the Dutch, German, and Danish coasts is not unattended by a destruction of immature flat-fish corresponding to that which I have shown to take place on our own coast.

Whatever other factors may have been at work in the admitted deterioration, there can be no doubt that the above furnish ample cause for at least a great part of the decrease, and if any method can be devised to check these evils alone, we shall be in a fair way to a revival of the supply. It behoves us therefore to consider, as carefully as a limited space will permit, whatever propositions have been brought forward with this view.

These fall chiefly under the following headings:

(i) Prohibition of sale of fish under certain sizes.
(ii) Extension of the territorial limits.
(iii) Close seasons.
(iv) Restrictions of mesh.
(v) Artificial propagation.

Other suggestions have been put forward, and will be discussed in turn, but hardly merit separate enumeration.

(i) *Prohibition of sale of fish under certain sizes.*

A brilliant suggestion that the *capture* of undersized fish should be prohibited need not detain us long, since it is obviously impossible to avoid catching some undersized fish if one fishes at all, and what benefit could be expected from a legal prohibition of this sort I am at a loss to conjecture, since the law could not possibly be enforced as long as a fisherman was allowed to go to sea. There are, of course, methods by which the capture of a very large proportion of undersized fish can be prevented, but prohibition of capture, *per se*, is not one of these.

We may pass, therefore, to the question of prohibiting the sale, accompanied or not, as the case may be, by similar restriction as to landing.

This is the remedial measure which has found by far the greatest number of advocates, but there has been a very considerable difference in the sizes advocated. It may seem at first sight that this is of comparatively little importance, so long as the principle of prohibition of sale is agreed to, but in reality the principle involved depends entirely upon the size to which the prohibition refers.

We have seen, in Chapter I, that the standard of size may be arrived at by two entirely different methods, according to whether it is sought to discriminate (*a*) between sexually mature fish and those which are too small to reproduce their species; or (*b*) merely between marketable and unmarketable fish. Of course the former standard is considerably the higher in all flat-fish of any considerable value (excepting the lemon-sole in the North Sea), while both standards are subject to variation according to locality.

Of late years I do not know that the enforcement of the biological limit has been much insisted on, except in cases where it chances to fit in with what may be called the economical opportunities of the situation. Its advocates content themselves rather with the pious opinion that it is desirable that fish should have a chance of reproducing their species at least once before they are destroyed. Moreover, at least one authority of the highest standing, Dr. C. G. J. Petersen, holds that the deterioration of the fishing is, in the case of plaice, certainly not owing to a want of spawn, since, with regard to young plaice, he finds "that it is hard to imagine there could be any more individuals than there are."* Petersen's remarks refer here to the Cattegat, and do not profess to say whether the young fish are actually as numerous now as in former years. He simply suggests that there are enough to furnish a remunerative fishery if they were not destroyed at too small a size. On the North Sea grounds our fishermen are emphatic in their statements that even the small fish are much less numerous than they used to be, and I do not think there is any reason to doubt their accuracy in this particular. If it is so, although the fry may be numerous enough to supply the existing fishery when grown up, there must still be an insufficiency of spawn, since I take it that the ideal condition would be that the grounds should hold the greatest possible head of fish which they can maintain. The fishery is growing, and presumably will grow, and the problem which we have to face is not only to try and provide for immediate wants, but in so far as lies in our power to maintain the grounds at the greatest possible degree of productiveness.

The objection to the biological limit is, of course, that by cutting off a large supply of marketable but immature fish, it bears hardly both on the producer and the consumer, and especially the latter; while there is no apparent way in which it can be enforced with absolute certainty of benefit to the supply. In this connection it will be remembered that we have seen that the conditions of deep-sea trawling are not favourable to the return of undersized fish in a healthy condition, and therefore if, as we know to be the case, mature and immature fish are caught together on certain grounds, the latter have but little chance of surviving the process.

What we have to strive for is a method which shall combine the maximum preservation to the species with the minimum hardship to the producer and consumer. Some hardships there must be, at least of a temporary nature, for if the matter could be arranged without inconveniencing anyone, it would naturally arrange itself without legislative assistance.

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* *On the Decrease of our Flat-fish Fisheries*, Rep. Danish Biol. Stat., 1894, p. 62.

Turning to the size limits recommended by the trade, we find that such are designed, not to admit of the propagation of the fish before it comes to market, but to prevent, in so far as may be possible, its destruction before it has attained the size at which it has a considerable commercial value. The limits recommended by the representatives of Grimsby and Hull were originally such as to exclude rather a large proportion of fish (excepting turbot and brill) which were actually saleable, even if not commanding much of a price. The same limits, as we have seen, did not commend themselves to our South Coast fishermen, and, with view to presenting an unanimous appeal to the legislature, the matter was compromised by the adoption of the limits approved by the Conference of 1892 (see p. 381). It cannot, however, be said that the whole trade expressed itself in favour of the enforcement of these limits, or, indeed, in favour of any legislation based on the adoption of a size limit. Lowestoft, in fact, in the mouth of the witness chosen to represent the smack-owning interest of that important trawling centre, objected strongly to any limit at all; but as the objection was based on an assertion that unmarketable fish were not taken by Lowestoft trawlers, it is hard to see how the prohibition of the sale of such unmarketable fish could injuriously affect the trade. We are entitled, I think, to say that as far as this port is concerned, the statements put forward as evidence are in themselves enough to dispose of the objections to a size limit; but we must note that the Lowestoft standard of discrimination between large and small fish (plaice) appears to be about 8 inches, instead of the somewhat higher figure advocated by Grimsby and Hull.

It was only to be expected that the longshore fishermen should object to a size limit, since the only fish within their reach, with the exception of an occasional sole, fall for the most part far short of any standard advocated. Personally I am inclined to consider that the interests of the longshore fishermen are, in this matter, not entitled to any consideration. In so far as the shrimpers are concerned, the most injury that could befall them by the imposition of a size limit would be the elimination from their saleable catch of a certain number of small flat-fishes, chiefly plaice. Flounders and dabs, and a few marketable soles, would remain saleable, as before. As for inshore fish-trawling, flat-fish netting, and the like, it cannot be denied that these pursuits, having for their object the capture of immature fish only, are entirely contrary to the public interest, whether of the consumer or of the trawl-fishery as a whole, and if the enforcement of a standard of size should have the effect of suppressing these methods of fishing, the public would gain thereby considerably.

We may now consider the probable effect of the various standards of size placed before the Parliamentary Committee, other than those based on the consideration of sexual maturity. The Conference of 1892 dealt with five species, and proposed, as we have seen, the following sizes:

Turbot	12 inches.
Brill	12 ,,
Sole	10 ,,
Lemon Sole	11 ,,
Plaice	10 ,,

With regard to the North Sea, I have always failed to understand what beneficial effect could be expected from the limit of 12 inches proposed, as above, for brill and turbot, since the same limit may be said to be in operation already. One hardly ever sees either a turbot or brill of less than 12 inches in the Grimsby market, and I do not think that many of less size are caught on any ground worked by deep-sea trawlers. It must be supposed that the originators of the suggestion had some object in view, and we know that there are well-founded complaints as to the scarcity of these two valuable fish, but the limit proposed would leave the matter precisely in the condition in which it is at present.

The limit of 10 inches proposed for soles would certainly benefit that species as far as concerns our own inshore fisheries, but, for the reasons already urged, soles of less size taken in deep-sea trawling operations would not be likely to receive much benefit from the enforcement of the standard. If any standard is adopted, I think that in the case of a fish so extremely valuable and so scarce as the sole, such standard should not be short of the biological requirements.

The lemon sole, in that it is not largely taken in the immature but saleable condition on the Eastern grounds, stands probably in less need of protection by means of a size limit than the others; and to my mind the value of legislation by size limit stands or falls entirely with the size which is adopted in the case of plaice.

Now, when dealing with the destruction of small fish, I have, as I suppose, given ample evidence that an immense number of plaice of *more than* 10 *inches*, the size proposed by the Conference of 1892, are captured on the Eastern grounds in company with hosts of smaller ones, and there is an absolute consensus of opinion that when once the small fish have been caught on these grounds, there is very little likelihood of any of them surviving, if returned to the sea. Consequently, if after eliminating all fish which are of less than 10 inches, there remain enough to be a source of profit to the fisherman, the only effect of prohibiting the sale of the smaller ones would be to ensure the fouling of the grounds with their carcases, and to cause a great waste of food with no corresponding benefit.

The ordinary catch of a boat working the Eastern grounds consists of a large number, it may be several hundred, of boxes of plaice from 15 down to 8 or even 6 inches ; a lot of turbot, nearly all immature ; and a number of brill, mostly mature, but still of no great size. If the right grounds have been worked, there may be from half a box to about two boxes of soles. On certain of the grounds the soles are the avowed object of the fishery, but now-a-days they are not nearly plentiful enough to pay the expenses of the voyage, much less to secure a profit. It is the small plaice which pay the expenses, and if we could stop the sale of these we might assure ourselves that no one would go near the grounds ; but if we only stop the sale of those of less than 10 inches, we shall leave a quantity quite sufficient to pay the expenses ; thus, though the profits of the voyage may be a little less, the fishery will go on as before, and the same quantity of small plaice, turbot, brill, and soles will be destroyed as before, though the consumer will get fewer of them. Where does the advantage come in ?

If, on the other hand, we raised the limit for plaice to 13 inches, as I have proposed to do, we shall cut off so large a proportion of the catch that it will not be worth while for boats to go to the Eastern grounds. At the same time we shall ensure that the small plaice which annually migrate from these grounds to the Dogger shall not be intercepted on the way, since there are not enough fish of other sorts on the migration track to attract vessels thither if the small plaice were unsaleable. I have shown that the proportion of plaice under 13 inches on the off-shore grounds of the North Sea is inconsiderable, at any rate in the summer, and consequently whatever waste might be caused by the size limit would be of little account. The limit need only be enforced during the spring and summer, say from March 14th to September 30th, as for the remainder of the year the small fish are not to be found on the Eastern grounds, while those which have migrated in the autumn are mixed up on offshore grounds with larger fish, and could only be sorted with difficulty.

I contend, and I do not see how it can be denied, that by the mere imposition of a size limit of 13 inches on plaice alone from March 14th to September 30th we should leave the Eastern grounds entirely

untouched, to serve as a nursery for the whole North Sea for plaice, turbot, and to a less extent of brill and soles, and as a spawning haven for soles, brill and turbot.

There are certain objections to the plan, to which we must return later, turning our attention for the present to the recommendations of the Parliamentary Committee.

The Committee found themselves unable to recommend either the biological limits (though I am not aware that these limits were recommended for legislative purposes) or those of the Conference of 1892. They considered that "while it might be desirable to forbid the sale of small flat-fish, the adoption of the sizes suggested would involve great hardship to many of the poorer fishermen who fish near the shore in the smaller class of boats." The Committee seems to have been further dominated with a fear of originality, and considered that the size limit adopted should approximate to that already adopted by foreign countries.

Such limits are as follows:

Belgium—

Plaice . . .	7·2	inches total length.
Soles . . .	7·2	,, ,,
Turbot . . .	10	,, ,,
Brill . . .	10	,, ,,

Denmark—

Plaice . . .	8	inches from nose to root of tail.
Turbot . . .	8	,, ,, ,,

France—

Plaice . . .	5½	inches from eye to root of tail.
Sole . . .	5½	,, ,, ,,

The limits recommended for the United Kingdom are:

Plaice . . .	8	inches total length.
Sole . . .	8	,, ,,
Turbot . . .	10	,, ,,
Brill . . .	10	,, ,,

So far as the North Sea is concerned, this brilliant proposition cannot be said to make any important difference in the existing condition of the fishery. As a matter of fact the only fishermen whom it will in any way affect are the longshore men, whose interests the Committee were so anxious to safeguard. Inshore fish-trawlers and shrimpers will be deprived of a certain number of marketable plaice and soles; the deep-sea men will be deprived of nothing:—they catch no soles under 8 inches, and few, if any, which are as small, on the Eastern grounds, while if they have to shovel over a few more plaice than they do at present, the difference will do them no harm,—and the fishery no good. Before one can sell a fish, it is necessary to catch it, and as our deep-sea boats do not catch turbot and brill of less than 10 inches, such part of the recommendation as refers to these species might as well have been omitted.

In fact the Committee's recommendations leave the deep-sea trawl-fishery of the North Sea, the deterioration of which was the primary cause of the inquiry, absolutely untouched; they cut off some little from the catches of inshore fishermen—enough to annoy them, but not enough to do any material good to the supply of the species concerned.

In face of the evidence offered, it is rather difficult to understand by what mental process the above result was arrived at, until we take into consideration the conflicting interests of different parts of the coast. It is quite evident, from the experience of my colleague Mr. Cunningham, that there is very little destruction of immature flatfish by the deep-sea trawl-fishery of the south-west coast, and consequently no need of legislation by size limit as far as that industry is concerned. It appears, however, that such legislation would have a beneficial action on certain inshore fisheries of that district, but we are met by the fact that the plaice of the south-west coast are altogether smaller than those of the North Sea. It follows, therefore, that any limit of size, high enough to be beneficial in the North Sea, would be too high for the south-west coast, since it would render unsaleable a large number of actually mature fish, and seriously and unduly interfere with the operations of offshore trawlers. This, I think, is a sufficient argument against the *universal* imposition of a high limit of size, the more so as I can see no reason why the limit should be universal.

The practical application of different size limits to different districts has been held to be extremely difficult, but the difficulty has certainly been overrated. Fish must be landed somewhere, and from my own experience of the Grimsby market, I am convinced that a fishery officer could without difficulty exercise a sufficient control over the size of fish landed. The Parliamentary Committee, though they mention that the prohibition of *landing* as well as of sale was suggested to them, do not make any recommendation on this head; but to most people it will appear to be only a matter of common sense that, if sale is prohibited, it should be made equally unlawful to land the undersized fish. It has been suggested that if we prohibit the sale of fish under a certain size in one district, and permit it in another, fishermen will evade the law by running their catches to some port where the smaller size limit is in operation. Doubtless this might be the case if we were dealing with fish of great value. If, for instance, there were a different size limit for soles in different districts, and large quantities of small ones could be caught, it might pay to run them to the district where the size limit was the smallest. But we are dealing with plaice, and plaice of less than 13 inches do not command much of a price anywhere, while the best markets are on the east coast and at London. On this account North Sea boats, by running to ports on the south coast to sell their fish, would lose more in time and expenses than they gained by being able to sell the very small plaice. I should think that the southern shore of the mouth of the Thames would make a practical boundary as between the North Sea on the one hand, and the southern and south-western coasts on the other. Moreover, the prohibition of sale or landing with regard to districts would naturally be accompanied by enactment making it unlawful to evade the operation of the measure in the manner suggested, and no fishery officer worth his salt would find any difficulty in detecting an attempt to land fish from the Eastern grounds of the North Sea on the south coast, in the very improbable event of such an operation being attempted. It is perhaps not too well understood by the general public, as well as by others who have less excuse for their ignorance, that there are certain local characters in flat-fishes which are perfectly well known to every one who has much experience of fish and fisheries; and we may at least credit those in authority with sufficient sense to choose their fishery officers only from amongst those who are qualified for the task.

(ii) *Extension of territorial limits.*

Next to the imposition of size limits, the scheme for restoring the fish supply which finds the greatest number of advocates is the closure of certain areas to trawling. In virtue of international law the boats of one nation are already excluded from the territorial waters of any other; in our own country, the District Committees in England, the Fishery Board in Scotland, and the Fishery Office in Ireland, have power to prohibit trawling in their respective spheres of influence. Of these powers the authorities in question have already very largely availed themselves; whether they have done so with a view to the protection of immature fish, or to keeping Her Majesty's peace as between trawlers and drift-net or line fishermen, does not greatly signify, though one may be permitted to express an abstract regret that the powers of a fishery authority should occasionally be degraded to the level of parochial politics. It is admitted that, in so far as concerns the North Sea trawling industry, the remedy is beyond the utmost territorial jurisdiction of our own country, since the injury complained of takes place on the Continental coast rather than on our own.

The proposal is that a large part of the ground frequented by small fish should be closed to trawling by international agreement, since the grounds extend far beyond the jurisdiction of any one power. We have already seen that the whole coast from the Horn Reef in Denmark to Terschelling Island in Holland is practically one vast nursery of small plaice, and it is proposed along this area, or part of it, to extend the territorial limit by international agreement to ten or twelve miles, and to prohibit trawling within this limit to the vessels of all nations.

The plan is absolutely the most perfect which could be devised, if only it could be regarded as in any way practicable; but this, unfortunately, is not the case. It is, perhaps, within the bounds of possibility that the nations owning the stretch of coast in question might unite with Great Britain in closing this area, but it would then be closed only to British, Danish, German, and Dutch vessels, and as long as the actual three mile limit were respected, there would be a direct incitement to the enterprise of some other nation. France, I believe, has always expressed herself unconvinced as to the necessity of international action in fishery matters, and it may be imagined that the result of abstention by the other nations would be the establishment of a French trawling industry, fishing along the Continental coast, and selling the small fish, which we wish to protect, in our own markets.

But this contingency is remote, since there is not the slightest reason to suppose that the other Continental powers would consent to the scheme. Their interest in the deep-sea trawl fishery is but small; and, on the other hand, a very large fishing population is engaged in trawling operations in small boats along the coast. Moreover, as they are perfectly entitled to urge, these small boats are destructive only to marketable fish. The inshore plaice fishery, on the Danish and German coasts at any rate, is, as I have pointed out before, and as has been recently confirmed by Dr. Petersen, essentially a "live-fish" trade. The marketable fish are picked out of the net before the latter comes on board, and the smaller fish turned loose without ever coming on board at all, and it is very rarely that any are injured by their temporary sojourn in the net. It is not to be expected that because our large trawls destroy a large quantity of undersized fish, foreign nations will sacrifice their own interests for our benefit; for we, as having the deep-sea trade practically in our own hands, should undoubtedly reap by far the greatest share of the benefits which might accrue from closing these areas. The Continental fishermen would be debarred from working the only grounds they can reach, for the recuperation of grounds whither their small boats dare never venture.

On this account I think we may be perfectly certain that the international closure scheme is purely visionary. It has the further disadvantage of being impossible to enforce. The stretch of ground is so enormous, and extends so far from the coast, that it would pretty well take the entire navy of Europe to look after it, while the necessarily heterogeneous nature of the police force would not tend, as I imagine, to international amenities.

Leaving international action out of the question, we have still the power of preventing our own boats from fishing these grounds, or rather, of prohibiting their doing so ; and as the bulk of the injury is inflicted by our own fishermen, it may be held that, by putting a stop to their operations, we should close the grounds sufficiently to allow of the recuperation of the supply. This is true enough, but if we abstained, assuredly other nations would step in, since our markets, in the absence of a size limit, would still be open to small plaice ; and in the end, I suppose, the result would be to place our fishing fleet under a foreign flag, just as the unappreciated attentions of the Board of Trade are said to be alienating our Mercantile Marine at the present day.

(iii) *Close seasons.*

The institution of close seasons for some of the more valuable trawl-fishes has occasionally been suggested, but it needs very little reflection to see that it is in no way practicable, except, possibly, in connection with certain defined areas.

From my remarks in a previous chapter it will have been seen that the spawning of different kinds of fish is by no means simultaneous, but that for at least nine months of the year there are one or more valuable species spawning. To establish a close season for one or more kinds, while permitting the rest to be sold, would be folly of the most inconceivable kind, since we know that, once the fish is caught in the deep-sea trawl, it matters little whether it is thrown back or brought ashore. It is killed in either case—in nine cases out of ten. Therefore, if we wish to establish a close season for any one trawl-fish, without regard to area, we must establish a close season for all trawl-fish at the same time, and thus stop trawling altogether. This, I imagine, is altogether out of the question, as it would ruin the trade.

Even with regard to defined areas there are great difficulties in the way of a close season, but it might be possible to close a piece of ground for a certain time with a view to the protection of one species. The sole seems to offer the best opportunity, while it is also the species which is perhaps most in need of this form of protection. It would be possible, perhaps, to obtain an international consent to the closure of the Terschelling sole ground for a month during the spawning period, and such a limited area could be watched without great difficulty. The landing and sale of soles might be prohibited at North Sea ports and at the London markets during the same period, since I do not know that soles are to be got anywhere else in the North Sea at that time of the year. This would probably have the effect of checking the Dutch sole fishery, as the market for its products is to a great extent in England, and thus the species would benefit on other grounds besides that specially intended.

I am not prepared to speak very strongly in favour of this proposition, and merely put it forward as the only form of close season which seems in any way practicable in the North Sea.

(iv) *Restriction of mesh.*

Legislation based on the size or pattern of mesh or on the nature of the fishing engine to be employed commends itself, perhaps, rather to the amateur than to any one who has had much experience of fishing operations.

The great difficulty with regard to the mesh is found in the fact that fish of different kinds exhibit widely different characters of conformation as well as of size, so that it is actually impossible to devise a size or pattern of mesh which shall be equally suitable to all sizes and patterns of fish. Moreover, apart from their difference in conformation, some kinds of fish are very much more agile than others, and the comparative agility of the different component items of the catch has to be taken into consideration no less than their proportions.

Without wearying the reader with details of breadth in proportion to length, &c., the applicability of the above remarks may be sufficiently illustrated by a comparison of two such well-known forms as the sole and the plaice. Every one interested in such questions should know that a sole reaches maturity at a width which, in the plaice, is associated, not only with complete immaturity, but with a market value so low as to be hardly estimable. Further, any one who has had any experience of trawling, or has even had the opportunity of examining a sole in the living condition, is well aware that this fish is infinitely more active and sinuous than the plaice, and can, and will, escape from the net if there is any possible means of doing so. A plaice, on the other hand, may be caught in a net, the meshes of which, to the uninitiated observer, seem to offer every facility for its escape.

Now, among flat-fishes it is the plaice which (as constituting, with the haddock, the trawler's "staff of life") stands in the greatest need of protection, yet it will be conceded that we should not be justified in so enlarging the mesh, for the benefit of young plaice, as to deprive the fisherman of actually mature soles. Besides this, no mere enlargement of mesh, associated with the apparent opportunity of escape for the species to be protected, would serve the purpose. A net ashore, dry, and with no strain on its meshes, is a very different affair from the same net in actual use, towed along at the rate of two or three miles an hour, with a hundredweight or so of fish and assorted rubbish in the cod end. It may seem to be the easiest thing in the world to protect a plaice of, say 4 inches in breadth, *i. e.* about 9 inches in circumference, by making the meshes of the cod end of the same circumference. Judging from the appearance of the dry net, the fish should have no difficulty in pushing its way out; but, as a matter of fact, when the strain is on, the sides of the meshes are practically closed.

It has been contended that, as the vessel rises and falls on the swell, there is an alternate strain and relaxation on the mesh; probably this is to some extent true, but to a very small extent only, as, when we take into consideration the length and weight of warp out, it seems reasonable to suppose that by the time the motive power is communicated to the net it is to all intents and purposes continuous. However this may be, the fact remains that though the sole (which never ceases to hunt for a loophole of escape until it either finds one or jams itself inextricably in the "pockets"), may escape, a plaice of the same actual circumference does not. It is certainly true that with every enlargement of the mesh a larger proportion of small flat-fish escape; but it is equally true that, to ensure the escape of any significant number, the enlargement has to be carried to such an extent, that the net becomes absolutely useless for the capture of the narrower and more active species. In fact, the relation of size of mesh to size of fish caught, seems to be nearer, in the case of plaice and dabs, to the greatest possible circumference (*i. e.* as measured lengthways) than to the least circumference of the fish; and we may safely say that a net successfully devised for the escape of undersized plaice would catch no soles at all. Much less, therefore, is it practicable to protect young turbot and brill by this method.

There is, however, no doubt that an increase in the size of the mesh is beneficial to small round fish, though even in this case I do not think it is practicable to carry it to such an extent as to protect, even partially, all immature members of any valuable species except the whiting. Of course, the ingenuity of man in this respect is always subject to utter frustration by the capture of a quantity of weed, mud, or rubbish of any sort, but that appreciable results may be accomplished by mere regulation of size of mesh has been sufficiently demonstrated by the experiments of Mr. Dawson on behalf of the Lancashire Sea Fisheries Committee, to whose observations I would refer readers for particulars.

So far my remarks must be interpreted as applying only to mesh of the ordinary pattern, viz. braided diamond-wise, so that the knots offer the least possible resistance to the longitudinal closure of the meshes. My own experiments, carried on as opportunities have from time to time permitted, have rather led me to the conclusion that, for purposes of deep-sea trawling, it is impracticable to seriously affect the situation by any mere enlargement which the requirements of the case permit. The mesh in the cod-end of Grimsby trawls varies from 1½ to 3 inches "knot to knot," *i. e.* ¾ to 1½ inches "square," or 3 to 6 inches in circumference. I do not think substantial hardship would ensue from the prohibition of a mesh of less than 8 inches in circumference in the cod end, but at the same time, I am far from sure that the benefit ensuing therefrom would be altogether in proportion to the disturbance of the industry. The 6-inch mesh is, I think, the more popular with the fishermen, and I have heard complaints that the owners gave them needless trouble by supplying a mesh which augmented their catch only by rubbish and mud.

It seemed to me, however, that if little could be done in the way of a profitable and at the same time practicable enlargement of the mesh, there was some opportunity of improvement in its pattern. As we have already seen, the meshes are arranged in such a way that the twine of the knots offers the least possible resistance to their closure. It occurred to me that by braiding the meshes for the cod end in the ordinary way, but arranging this part of the net so that the meshes lay at right angles to their ordinary position, the extra strand of twine would offer some resistance to the closure of the sides of the mesh. My surmise was sufficiently borne out, as long as the net was tolerably new, since a cod end arranged in this way caught considerably less small fish than an ordinary cod end with mesh of the same size; but when the net had been thoroughly stretched the difference became inappreciable. Moreover, the transversely arranged meshes had the disadvantage of being liable to be pulled out of shape by the strain, whereas, in a net arranged in the ordinary way, the greater the strain the tighter the knots are pulled, and the more firmly the meshes are set in their right relationships to each other. On the whole, then, the transverse method of arranging the meshes cannot be recommended.

Every one is aware that a net with square meshes (*i. e.* with the sides of the mesh parallel and transverse to the long axis of the net) cannot close to nearly the same extent as a net braided in the ordinary diagonal fashion, and it requires no experiment to show that such a net will let out more small fish than one of the ordinary pattern. Consequently one often hears that the difficulty of the closure of the meshes can easily be adjusted by having the latter braided square instead of diamond-wise. The advocates of this plan, however, have overlooked one fact of the most vital importance. In the diamond-shaped mesh every strand bears an equal share of the strain, whereas in a square mesh the strain is borne only by the two strands which are parallel to the long axis of the trawl, the transverse strands contributing in no way to the strength of the whole engine. Hence it follows that to bear an equal strain, a square mesh must be braided of twine which is double the thickness of that required for an ordinary diagonal mesh. The net therefore requires to be twice as heavy. The square mesh would, of course, be confined to the cod end of the trawl, and in the case of a steam trawler I do not know that the extra weight would be of very great moment. To a sailing trawler any access of weight would be an intolerable infliction, as in a light wind the trawl is only too liable to "sand," as it is. Hence, as far as smacks are concerned, this method of dealing with the matter does not come within the range of practical politics.

It will be easily understood that the way in which the cod end is closed, must have an important bearing on the closure or non-closure of the meshes. The cod end is, as everyone should know, composed of two oblong pieces of net joined to each other along the sides. The fore-end of the resulting tube is laced on to the fore part of the net, while the after end is left open like the mouth of a sack. By Grimsby trawlers it is invariably closed before the net is shot, by gathering the meshes together and tieing a cord round the bunch of net so formed. This method is called "tieing" the cod end, and it is obvious that the bunching up of the net affords opportunity for the lodgment of every sort of rubbish which can possibly choke the meshes, besides in itself materially decreasing the possibility of their opening. Of course a cod end so "tied" is not difficult to untie when the net comes aboard. There is another method of closing the net known as "marling." Instead of bunching the mouth together, the "back" and "belly" thereof are simply "marled" or laced together.

It seemed probable that a "marled" cod end would let out more small fish and more rubbish than one which was tied, and some experiments which I made, though I could not carry them far enough to speak with absolute certainty, tended to the confirmation of this view. With a view to still further preventing the closure of the meshes I tried the expedient of lacing the back and belly of the opening to a pole, so as to stretch the meshes to their utmost transverse extent, but a casual encounter with an anchor brought this experiment to an abrupt conclusion, and I have never had an opportunity of renewing it.

I have been able, however, to make trial of another device, which seems likely to yield much better results than any other. In place of tieing the opening of the cod end in any way I procured an oblong wooden frame, across which were stretched square meshes of stout twine. The opening of the cod end was laced to this frame, so that the latter formed, as it were, the terminal wall of the whole net. Tested against cod ends of the same mesh, either marled or tied, this last method gave, as far as my experiments went, most satisfactory results, and everything that could pass through the meshes found its way into a large bag of shrimp mesh, which was fastened outside the lower end of the trawl proper. An objection urged against this arrangement was that the meshes of the frame, being stretched quite taut, would be apt to be broken by a stone or a heavy piece of wreckage, and thus the whole catch would escape. I have, however, safely boarded a stove chimney, an iron bucket, a pit prop, and similar things in the Humber without damaging the net, and there is no reason that the meshes of the frame should not be made of wire hawser, or even cast iron, if necessary. Of course a frame of this kind is rather a nuisance to unfasten, but the devising of a rapid method of opening it should not be difficult to any one with greater inventive ingenuity than I can lay claim to. To my mind the only serious drawback to the affair is that a wooden frame would soon get waterlogged and very heavy in deep sea work. Probably this could be remedied by having a frame of metal tubing (preferably aluminium) which would at the same time have a decidedly beneficial action in lessening the friction of the cod end against the ground.

At the time my frame was in use I first became acquainted with a somewhat similar device, in which the extremities of the back and belly of the cod end are separated by the introduction on each side of a triangular gusset of netting, the base of which is laced on to a rod of wood. The opening of the net is therefore oblong, and is closed by an oblong piece of netting corresponding to my frame. The principle is the same, but I think that my own expedient has a decided advantage in keeping the meshes of the terminal wall absolutely taut and wide open.

We must always return, however, to our original conclusion, that whatever scheme of beneficial mesh-restriction can be devised, it must be for the flat-fishes* at best only subsidiary to some much more far-reaching measure for their protection.

(v) *Artificial propagation.*

This method of restocking the sea may perhaps be said to be one of which the theoretical advantages are rather over-balanced by the practical difficulties. The public are at last awakening to the fact that the possibility of hatching and rearing a trout in a wash-hand basin does not imply a similar facility in the case of a sole or turbot; but it may be doubted whether even a thousandth part of the difficulties attending the artificial culture of sea fish is generally realised.

There is no doubt that the difficulties are by no means insuperable, given the necessary means, but it is, I imagine, entirely impossible to *rear* sea fish without a considerable initial expense in the way of rearing ponds. To merely *hatch* the eggs presents no particular difficulties, and involves only an expense which, compared with the outlay which would be necessary for rearing operations, is comparatively trifling. But the question arises—What is the good of merely hatching the egg and turning the larva adrift to fend for itself at its most helpless stage when exposed to countless enemies? If that is all our artificial propagation aims at accomplishing, I, for my own part, think we might as well leave the matter to the fish themselves, who may be supposed to understand it much better than we do.

There is no doubt whatever in my mind that if we are to accomplish any useful results, we must aim at rearing the young fish until it is reasonably well able to take care of itself. In the case of flat-fish the fry should be reared at least right through the pelagic stages. Granted that the difficulties of our present inexperience are successfully overcome, the prosecution of such operations on a scale sufficient to make any appreciable difference in the fish-supply would be very considerable, though the cost would not exceed that which the profits of the fish trade might reasonably be called upon to contribute.

But there is a further question of the utmost importance. Having reared the fry to the required stage, we should naturally enlarge it on grounds suitable to its habits at that period of existence. In the case of flat-fish such ground would only be found on the sandy margins ; and are we to go to all this expense and trouble merely for the pleasure of seeing our precious nurselings scooped up and carted away by the first shore shrimper who passed that way ?

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* Personally I have not studied the possibility of lessening the capture of small flat-fish in shrimp trawls by some alteration in the pattern of the net, but I believe that the officials of the Lancashire Sea Fisheries Committee have been experimenting on this question with some prospect of success. Their operations are based, as I understand, on the fact that a shrimp leaps higher than a flat-fish when the net approaches, and so a ground rope which will catch the former will pass over the latter.

I imagine the answer will be universally in the negative, and that it will be conceded that, before embarking on the culture of sea fish, we must take such measures as will materially lessen the probability of the money thus expended being altogether wasted.

My remarks have by no means included all the remedial propositions which have been put forward, but I think we have noticed all which deserve serious attention, and perhaps some which do not. With the minor suggestions we cannot here concern ourselves at any great length, but may notice a scheme put forward by Mr. Douglas, of Grimsby.

Mr. Douglas proposes to capture small plaice on the Eastern side, and transport them in well-vessels to the Dogger and to grounds on our own coast, and estimates that the cost of these operations would be amply covered by the increased catches of our trawlers. It is not at first sight apparent why the mere transference of fish from one part of the North Sea to another should increase the general supply. Putting this aside, and granting that the transference can be successfully accomplished, it is not easy to see how the small fish will benefit. No doubt there are some grounds on our own coasts, which are capable of maintaining a much greater head of fish than they hold at present, and which are practically deserted by our trawlers. But, if we dump down an immense quantity of small fish there, what is to prevent boats coming there at once and catching them if there is no hindrance to their sale ? As for the proposal of putting young fish on the Dogger, they are probably better off where they are in the summer (the only time at which they could be caught in anything like the numbers anticipated by Mr. Douglas), and in the autumn they do migrate to the Dogger, as we have seen, of their own accord. The plan of allowing them to do so in peace, by means of a suitable size limit, seems at once simpler and more efficacious than Mr. Douglas's scheme of State-aided emigration. The most that can be said for the scheme is, that if the fish were protected by a size limit and by the closure to trawling of such of our inshore grounds as are plaice nurseries, the large plaice grounds lying in the neighbourhood of our own coast might probably be recuperated rather more quickly than by the protection alone. Without the protection the whole affair would simply be a waste of money.

Conclusions.

A very few words will suffice to summarise the conclusions to which my previous remarks will have pointed. They are to the effect that the only practicable method of checking the depletion of the North Sea grounds and of enabling the fish supply to recover is by legislation based on the principle of the size limit.

Further, that the size limits proposed by the Parliamentary Committee are absolutely useless, and indeed ridiculous. No series of limits can be of appreciable use unless that assigned to the plaice is at least 13 inches. No lower limit will suffice to keep the trawlers off the Eastern grounds, where they will continue to destroy as much as ever, even if, in virtue of some smaller size limit, they land and sell less than at present. I would repeat that **these grounds can be absolutely closed to our trawlers, and to all trawlers whose catches are ultimately sold in this country, by a size limit of 13 inches for plaice, even if only enforced during the Spring and Summer.** It is not absolutely necessary to apply a size limit to any other species, though a size limit of 12 inches (or even 10 inches) could not fail to be beneficial to the sole, as tending to bring about the return to the sea of many small specimens which are caught in shrimp trawls and by inshore fish trawlers. The size limit of 8 inches for soles is altogether contemptible. It does not materially alter the present North Sea market customs in regard to the sale of this fish, and it has been aptly said of an eight-inch sole that, when you have taken off two inches for the head, and two inches for the tail, you are left with four inches of skin and bone in the middle!

It has been said that any legislation having for its effect the closure of the Eastern grounds would deprive our fishermen of their only chance of catching soles in the summer. Even if this were true, the sole is of such little real importance in comparison with the plaice, that I do not think the matter would be of much moment; but, in any case, it may be supposed that the relief of this spawning ground from our large fleet of trawlers would probably result in the reappearance of the species on other grounds which it has now practically deserted; and any increase in the species, even if confined in the summer to the Eastern side, could not fail to make itself felt in the winter in the Silver Pits.

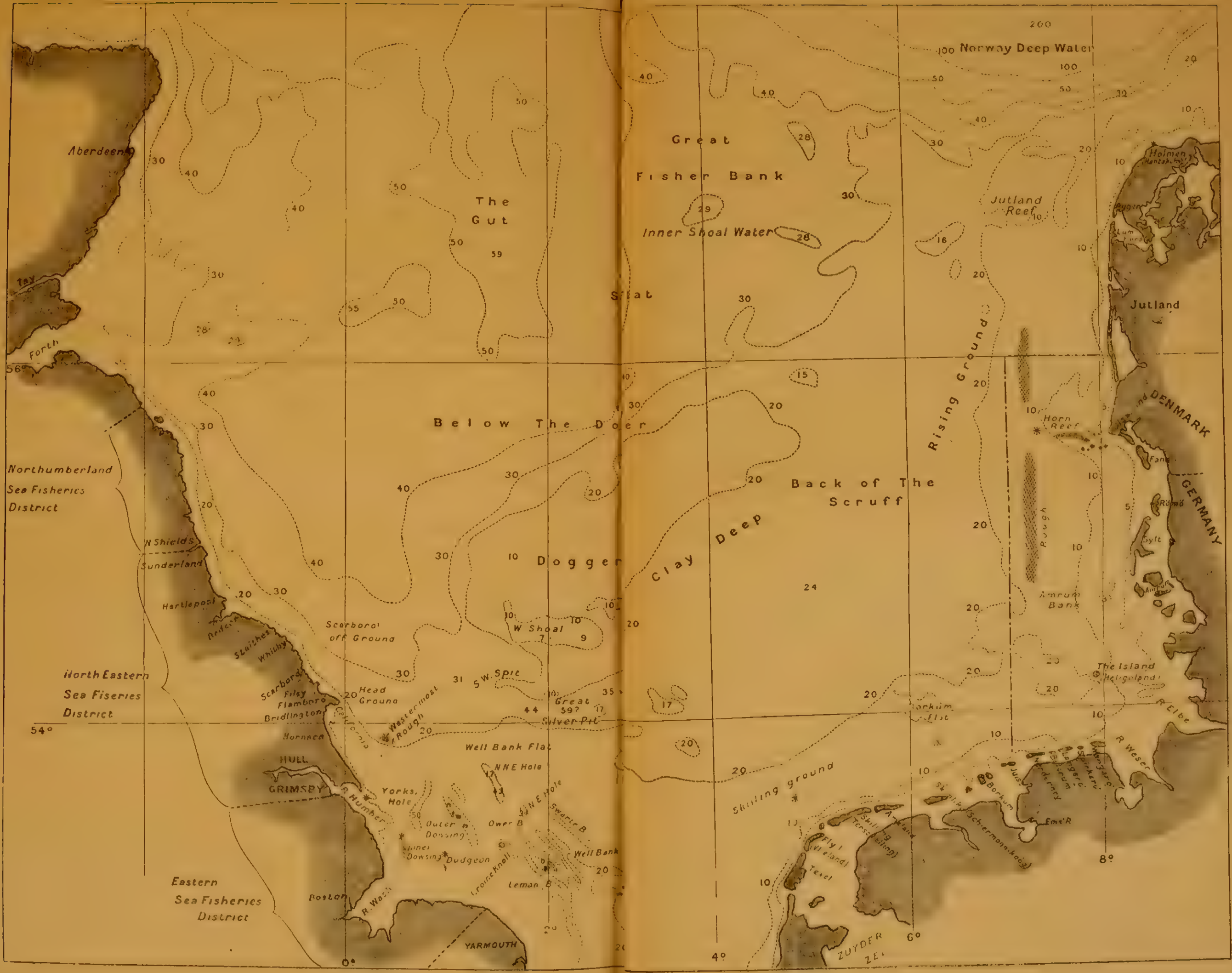
Returning to the plaice question, it is urged that the foreign vessels would continue to catch them as before; but this is not the case, as the chief market for these fish is in our own country, and therefore our restrictions of sale would react on foreign vessels as much as on our own. There is no foreign market which would tempt our boats to take cargoes of small plaice thither, and if such should be created in the future, I believe the beauties of free trade are not so thoroughly appreciated on the Continent as to allow of the long duration of a trade of this sort. The drawbacks entailed by the elimination from our markets of the large quantity of small plaice at present landed there are not of great importance, since I understand that the small plaice trade is chiefly of a speculative character, and not much affected by salesmen of repute.

I need hardly repeat that whatever penalty may attach to the sale of undersized fish must attach equally to their landing, and that it is essential that different districts should be treated according to their respective requirements. The remarks which are given above apply to the North Sea; whether any, and, if so, what size limit is required in other districts, I do not pretend to determine, since all the information which I have on the subject is equally available to the general public. This much is certain, that the matter cannot be rationally treated except in relation to the requirements of the locality, and there is absolutely no valid objection to discrimination as between one coast and another.

I cannot accept the Committee's argument that the hardship to inshore fishermen involved by a rational size limit is a valid reason against the employment of the latter. To me it appears that the destruction of immature fish stands on much the same footing as the pollution of rivers and other nuisances formerly associated with manufacturing enterprise. No doubt the measures taken against this pollution involved hardships to the manufacture, from the capitalist down to the factory hand, but the public has none the less approved them. Personally, if one may be permitted to illustrate so dry a controversy by a reference to humorous literature, the relative merits of the inshore and deep-sea fisherman in regard to the destruction of small fish seem to me to stand on much the same footing as the Walrus and the Carpenter in "Alice through the Looking Glass,"—one ate more oysters than the other, but the other ate as many as he could get! However, if the assembled wisdom of Parliament chooses to consider that its business is rather to settle the squabbles of rival classes of fishermen than to take measures to increase the fish supply, one can but regret it.

As to the other remedial propositions noticed, I need only repeat that an extension of the territorial limit, however desirable, is not practicable. A close season without an absolute cessation of trawling is useless, restrictions of mesh are only practicable within limits which would not permit of flat-fish being very materially benefited, though they are desirable in the interests of young round-fish which cannot be protected by the size-limit method. Artificial propagation must, to be really useful, include not only the hatching of the eggs but the rearing of the fry through the pelagic stages, and must most certainly be preceded by such measures for the protection of the young, as would very probably render it entirely unnecessary to embark on this very costly undertaking.

CHART OF T NORTH SEA.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Dogger
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Scruff
Rising Ground
Norway Deep Water
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GERMANY
Horn Reef
Fanö
Römö
Sylt
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Amrum Bank
Amrum
The Island
Heligoland
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R. Weser
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Westermost Rough
California
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Great Silver Pit
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